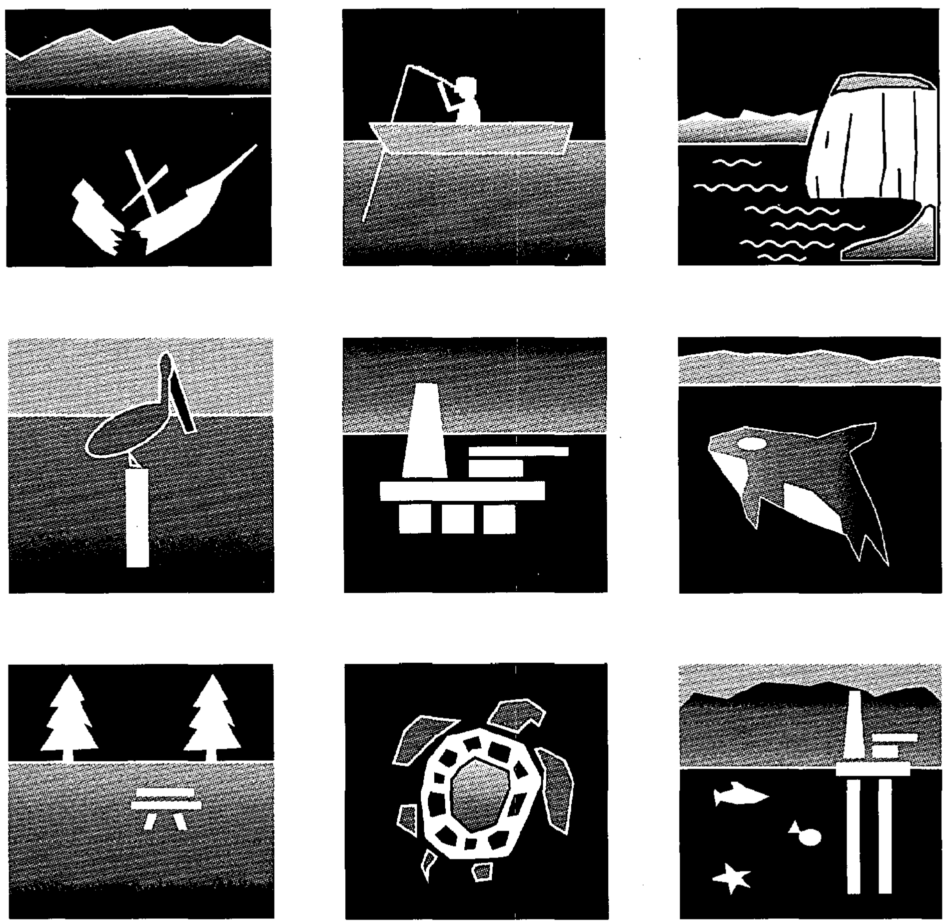
OCS Report
MMS 95-0007

Outer Continental Shelf Natural Gas and Oil Resource Management Program:

CUMULATIVE EFFECTS
1987-1991



MMS U.S. DEPARTMENT OF THE INTERIOR
MINERALS MANAGEMENT SERVICE

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Outer Continental Shelf Natural Gas and Oil Resource Management Program:

CUMULATIVE EFFECTS 1987-1991

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Overview

Section 20(e) of the Outer Continental Shelf Lands Act (OCSLA) Amendments of 1978 requires the Secretary of the Interior to submit annually to Congress an assessment of the cumulative effects on the human, marine, coastal, and socioeconomic environments from the Outer Continental Shelf Natural Gas and Oil Resource Management Program (OCS Program). "Cumulative effects" are defined as the total identifiable long-term effects that: (1) are attributable to activities authorized under the OCSLA; (2) are evident during the time period analyzed; and (3) can be quantified or evaluated. This report contains an assessment of the cumulative effects from OCS Program activities that occurred from 1987 through 1991. It does not evaluate effects from potential Outer Continental Shelf (OCS) activities or non-OCS-related activities/events. For an assessment of cumulative effects prior to 1987, see *Oil and Gas Program: Cumulative Effects* (Van Horn et al., 1988).

From 1987 through 1991, in response to the reduced margin between revenue and cost on the OCS, many major oil and gas production companies reduced their OCS-related activities and moved the bulk of their exploration and development activities overseas. Consequently, smaller companies were able to expand their share of the OCS market. Because the increased presence of smaller companies did not offset the loss of major oil and gas companies, a gradual decline in OCS activities was noted during this period (USDOI, MMS, 1992a).

During the 5 years covered by this report, the following OCS-related activities occurred.

- 16 natural gas and oil and 1 salt/sulfur lease sales were held
- over $3.3 billion in bonuses and $11.4 billion in royalties were collected
- over 2,200 exploratory wells were drilled
- over 2,100 development wells were drilled
- over 1.6 billion barrels of crude oil and condensate were produced
- over 22.5 trillion cubic feet of natural gas were produced
- over 500,000 short tons of salt were produced
- over 1.75 million short tons of sulphur were produced
- approximately 825 OCS platforms were installed
- over 3,690 line miles of pipeline were installed
- approximately 450 OCS platforms were removed
- approximately 36,000 barrels of OCS crude oil and condensate were spilled

Although identifying OCS activities that occurred during 1987 through 1991 is straightforward, isolating OCS-related cumulative effects from those associated with other factors affecting the natural and manmade environments can be difficult. Further, some "anticipated" effects are not realized because of preventive measures, such as stipulations, built into the regulations governing OCS leasing, exploration, development, and production.

Because environmental protection and operational safety are an essential part of the OCS Program, the Minerals Management Service (MMS) identifies potential risks associated with OCS activities in order to design special operating requirements to avoid or reduce those risks. The MMS Environmental Studies Program provides the information needed to predict, assess, and manage OCS effects on the marine and coastal environments. Likewise, the MMS uses a formal risk assessment approach based on ocean observations, numerical models, and historic data to assess the probability of occurrence and contact of hypothetical oil spills. Using information from these and other sources, the MMS develops special lease sale stipulations to eliminate or reduce many potential adverse effects before actual OCS activities take place.

The OCS leasing and operating activities are also regulated by Federal laws, and the MMS reviews OCS plans and drilling applications to develop or institute additional mitigation. Compliance with the MMS requirements and Federal statutes resolves many potential land, water, and natural resource use conflicts before OCS activities begin. Finally, to ensure operator compliance with OCS regulations, conditions, and stipulations, the MMS conducts inspections of all safety equipment designed to prevent blowouts, fires, spills, or other major accidents.

During 1987 through 1991, OCS activities caused only temporary, localized effects on most resources analyzed; however, there were cumulative effects in the following areas:

- Gulf of Mexico Region: wetland loss, coastal (nearshore) discharge of OCS-produced water, onshore disposal of OCS wastes, social effects, and recreation/tourism enhancement
- Pacific Region: social effects
- Alaska Region: social effects
- Atlantic Region: social effects

In general, the current OCS regulatory system prevents identifiable significant adverse cumulative effects from OCS-related activities on the human, marine, and coastal environments.

Abbreviations and Acronyms

A

ADFG	Alaska Department of Fish and Game
ADL	Arthur D. Little
APCD	air pollution control district
APD	application for permit to drill

B

bbl	barrels
BOD	biological oxygen demand
BOM	Bureau of Mines

C

CAMP	California Monitoring Program
CDFG	California Department of Fish and Game
CEI	Coastal Environments, Inc.
CFR	Code of Federal Regulations
CO	carbon monoxide
COE	Corps of Engineers (U.S. Army)
COST	continental offshore strategraphic test
CZM	coastal zone management
CZMA	Coastal Zone Management Act

D

dB	decibel
DPP	development and production plan

E

EIS	environmental impact statement
EP	exploration plan
EPA	Environmental Protection Agency
ESP	Environmental Studies Program

F

FAA	Federal Aviation Administration
FWS	Fish and Wildlife Service
FY	fiscal year

G

G&G	geological and geophysical
GOM	Gulf of Mexico

H

ha	hectare (2.471 acres)
H_2S	hydrogen sulfide

I

INC	incident of noncompliance
INTERMAR	Office of International and Marine Minerals Activities
ITL	Information to Lessee

J

JIMS	Joint Interagency Modeling Study

K

km	kilometer

M

m	meter
MMbbl	million barrels
MMS	Minerals Management Service
MMTC	Marine Minerals Technology Center

N

NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NORM	naturally occurring radioactive material
NAS	National Academy of Sciences
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NRC	National Research Council
NTL	Notice to Lessees and operators

O

OCS	Outer Continental Shelf
OCSLA	Outer Continental Shelf Lands Act
OSCP	Oil-Spill Contingency Plan
OS&T	Offshore Storage and Treating Vessel

P

PSD	prevention of significant deterioration

R

RTWG	Regional Technology Working Group

S

SO_2	sulphur dioxide
SO_x	sulphur oxides
SYU	Santa Ynez Unit

T

TSP	total suspended particulate
THC	total hydrocarbons

U

USCG	U.S. Coast Guard
USDOC	U.S. Department of Commerce
USDOI	U.S. Department of the Interior
USDOT	U.S. Department of Transportation
USGS	U.S. Geological Survey

V

VOC	volatile organic compounds

Table of Contents

4.0 Observed Effects of the OCS Program

5.0 OCS Marine Minerals Program

6.0 References

Tables

Figures

1.0 The Outer Continental Shelf Natural Gas and Oil Resource Management Program (OCS Program), 1987 Through 1991

1.1 Levels of Activity in the OCS Program

Natural gas and oil resources on the Federal OCS have been in production since the 1950's. In the past 40 years, the petroleum industry has acquired many valuable tracts leased from the U.S. Department of the Interior (USDOI), Minerals Management Service (MMS) and its predecessors. Drillers have already found and brought into production resources that were the easiest to find and least costly to exploit. The remaining deposits tend to be hidden under deeper water or located at greater drilling depths. In the face of continuing low international oil prices, these higher cost resources have reduced the attractiveness of many U.S. development projects on the OCS.

In response to the reduced margin between revenue and cost on the OCS, many of the major natural gas and oil production companies have curtailed their efforts and moved the bulk of their exploration and development activities to more promising areas overseas. The decline in activity by the major companies has created an opportunity for smaller firms, with lower overhead costs, to expand their share of the OCS market. Smaller firms, however, have also found themselves squeezed between high costs and low prices. Although the figures are not clear on the issue, the consensus among experts is that the United States is experiencing a gradual decline in OCS activities (USDOI, MMS, 1992a).

The numbers of tracts, exploration permits, wells, and platform emplacements seem to be trending downward. On the other hand, firms recently have been installing more miles of pipeline, although this practice may reflect discoveries farther offshore. Production, the most important measure of OCS activity, shows an unclear pattern. The general consensus is that Gulf of Mexico (GOM) oil production is on the decline, while southern California oil production is still growing. Although California OCS production levels are large, the increase is still insufficient to overcome the decline in the GOM. Natural gas production, on the other hand, set a record in 1990. However, due to the decline in exploration, this level may not be reached again. The recent increase in natural gas prices should soon show whether the industry can or will respond with greater OCS gas production.

Most financial measures associated with OCS oil activities have peaked and are headed downward. The most dramatic decline is in lease bonus revenues (for oil and gas leases). Both sales values and royalties on the oil produced and sold are also down, especially when taking into account inflation. Natural gas, however, shows a different picture. Gas sales and royalties reached records and may continue upward, at least for the near term.

1.2. OCS Lease Sales

From 1987 through 1991, the MMS held 17 OCS lease sales: 16 natural gas and oil, and 1 salt/sulphur. Table 1.2-1 summarizes the results of these 17 sales.

Table 1.2-1. Summary of OCS Lease Sales, 1987 through 1991

		Sale Offering			Bids Made			Leases Issued	
Sale	Date	Area	Tracts	Acres	Number	Tracts	Acres	Tracts	Acres
110	4/22/87	Central GOM	5,881	31,818,472	385	313	1,636,330	293	1,539,610
112	8/12/87	Western GOM	5,045	27,943,606	519	367	2,021,096	347	1,908,199
S/S	2/24/88	Central GOM	51	593,971	20	14	142,685	14	142,685
97	3/16/88	Beaufort	3,344	18,277,806	276	218	1,198,099	202	1,110,721
113	3/30/88	Central GOM	6,229	33,580,661	931	684	3,523,205	662	3,416,759
109	5/25/88	Chukchi	4,566	25,631,122	653	351	1,982,565	350	1,976,912
115	8/31/88	Western GOM	5,053	27,911,790	370	270	1,499,164	255	1,412,764
92	10/11/88	No. Aleutian	990	5,603,472	31	23	121,754	23	121,754
116-1	11/16/88	Eastern GOM	8,149	46,417,392	135	115	657,349	115	657,348
118	3/15/89	Central GOM	5,970	32,123,675	821	591	2,972,567	574	2,892,535
122	8/23/89	Western GOM	5,043	27,973,997	676	488	2,759,424	475	2,688,394
123	3/21/90	Central GOM	5,667	30,493,461	840	538	2,671,597	525	2,604,259
125	8/22/90	Western GOM	4,792	26,295,305	465	307	1,699,507	300	1,659,187
131	3/27/91	Central GOM	5,420	29,127,324	637	464	2,265,799	456	2,224,284
124	6/26/91	Beaufort	3,417	18,556,976	60	57	277,004	57	277,004
135	8/21/91	Western GOM	4,287	23,616,034	182	142	792,546	135	753,059
126	8/28/91	Chukchi	3,476	18,987,591	30	28	159,213	28	159,213

Source: Adapted from *Federal Offshore Statistics: 1991* (USDOI, MMS, 1992a)

1.3. Production-Related OCS Activities

During the 5 years covered by this report, operators on the OCS produced over 1.6 billion barrels of crude oil and condensate and over 22.5 trillion cubic feet of natural gas. These amounts represent 11.5 and 24.2 percent, respectively, of the total U.S. oil and natural gas production from 1987 through 1991. Table 1.3-1 (next page) specifies cumulative totals and yearly breakdowns of oil and gas production and other important production-related OCS activities. From 1987 through 1991, the OCS also produced over 500,000 short tons of salt and over 1.75 million short tons of sulphur.

1.4. OCS Revenue and Disbursement

From 1987 through 1991, the petroleum industry paid the MMS total bonuses of over $3.3 billion for the rights to develop OCS natural gas and oil resources. During this time, the petroleum industry paid royalties of over $11.4 billion on OCS production. Table 1.4-1 (next page) details specific sources of revenue and the disbursal destinations for some of these funds.

In addition, the salt/sulphur sale held in 1988 yielded over $15 million in bonuses. Salt production from 1988 through 1991 brought in $26,063 in royalties, while sulphur brought in over $12 million in royalties during the same period.

Table 1.3-1. OCS Production-Related Activities, 1987 through 1991

	Crude Oil & Condensate Production (MMbbl)			Natural Gas Production (tcf)			OCS-Related Activities				
	OCS	Total U.S	OCS as % of U.S.	OCS	Total U.S.	OCS as % of U.S.	Explor. Permits Issued	Wells Drilled[1]	Platforms Removed	Platforms Installed	Pipelines Installed (Line Mile)
1987	366	3,047	12.01	4.43	17.43	25.42	298	815	24	120	565
1988	321	2,971	10.79	4.31	17.92	24.05	313	970	102	178	711
1989	305	2,779	10.98	4.20	18.10	23.20	249	904	100	190[2]	774
1990	324	2,685	12.07	5.09	18.59	27.38	251	995	107	174	802
1991	316	2,707	11.67	4.15	18.69	22.20	170	660	115	143	844
Total	**1,632**	**14,189**	**11.50**	**22.18**	**90.73**	**24.45**	1,281	4,344	**448**	**805**	**3,696**

MMbbl = million barrels; tcf = thousand cubic feet
[1] Exploration and development wells only
[2] Includes two jackets installed in Pacific OCS Region
Source: Adapted from *Federal Offshore Statistics: 1991* (USDOI, MMS, 1992a)

Table 1.4-1. OCS Revenues and Disbursements, 1987 through 1991 (in Millions of Current Year Dollars)

	Oil & Natural Gas Leases			Crude Oil & Condensate		Natural Gas		Appropriations & Disbursements		
	Bonus	Rentals & Minimum Royalties	Royalties	Sales Value	Royalties	Sales Value	Royalties	LWCF	NHPA	States
1987	497	96	2,337	6,345	999	8,135	1,338	169	24	682
1988	1,260	80	2,058	4,815	747	7,946	1,310	193	27	367
1989	646	118	2,119	5,256	819	7,838	1,300	170	31	47
1990	584	99	2,630	6,981	1,091	9,458	1,539	206	33	49
1991	339	99	2,283	6,318	997	7,890	1,287	249	34	44
Total	**3,326**	**492**	**11,427**	**29,715**	**4,653**	**41,267**	**6,774**	**987**	**149**	**1,189**

LWCF = Land and Water Conservation Fund; NHPA = National Historic Preservation Act
Source: Adapted from *Federal Offshore Statistics: 1991* (USDOI, MMS, 1992a)

2.0 Administration of the OCS Program

2.1 The MMS Regulatory Program

The MMS administers the provisions of the Outer Continental Shelf Lands Act (OCSLA), as amended, through regulations found at Title 30 of the Code of Federal Regulations (CFR) Parts 200-243 and 250-282. These regulations govern natural gas and oil leasing operations on the OCS. In addition to regulating the conduct of operations on the OCS, these provisions allow for the following:

- public participation in leasing and postlease processes, including the review by and coordination with State governments
- consideration of State coastal zone management (CZM) programs
- solicitation of information from the public concerning proposed lease sales through a Call for Information and Nominations
- comments on environmental impact statements (EIS's)

In addition, the regulations provide for royalty payments and consultation with appropriate Federal and State agencies to develop measures for mitigating adverse effects on the environment.

The MMS consults formally and informally with the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (FWS) on the effects of MMS-administered natural gas and oil activities on endangered and threatened species under their respective jurisdictions. These consultations, conducted under Section 7 of the Endangered Species Act, may result in suggestions and recommendations promoting the conservation of listed and candidate species. They also may identify operational or other "reasonable and prudent" alternatives that preclude the likelihood of jeopardizing the continued existence of listed species or adversely modifying their critical habitats. The MMS pays close attention to these alternatives and recommendations when developing mandatory lease sale stipulations and discretionary Information to Lessees clauses. Their alternatives may also necessitate area-specific Notices to Lessees and Operators and special conditions in approved exploration plans (EP's) and development and production plans (DPP's). In all cases, the intent is to eliminate or minimize the adverse effects of natural gas and oil operations on endangered and threatened species.

The regulations under 30 CFR 250.33 require industry to submit to MMS an EP that includes measures to protect the environment. The MMS reviews the EP, analyzes the environmental effects, and determines appropriate mitigation before approving the plan. Additionally, regulations under 30 CFR 250.34 require industry to submit a DPP before development can occur. The MMS approves the DPP, if appropriate, taking into account environmental, technical, and economic considerations. Many other elements of offshore operations are covered in the MMS regulations that reflect the mandates of the OCSLA.

For the Central and Western GOM, the MMS uses a three-step analytical procedure (30 CFR 250.44-46) to evaluate potential air quality emissions and to determine whether air quality standards will be met at the shoreline during offshore natural gas and oil activities. For areas outside the Central and Western GOM, the U.S. Environmental Protection Agency (EPA) requires that the corresponding onshore regulations apply to pollution sources located within 25 miles of shore. (Note: The EPA promulgated regulations at 40 CFR Part 55 in September 1992.)

Regulations under 30 CFR Part 251 contain the requirements for prelease geological and geophysical (G&G) exploration for mineral resources on the OCS. Part 251 applies to G&G scientific research as well. These regulations prescribe the following:

- cases where a permit or the filing of a notice is required to conduct G&G exploration on the OCS
- operating procedures for conducting exploration
- requirements for disclosing data and information
- inspection and selection of data and information and conditions for reimbursing permittees for certain costs
- other conditions under which activities shall be conducted

Many Federal departments and agencies, besides the USDOI, regulate specific aspects of OCS operations. For example, the EPA regulates waste discharges; the U.S. Department of Transportation (USDOT) regulates occupational safety and health, the reporting and containment of oil spills, and the design of certain pipelines and mobile offshore drilling units; and the U.S. Department of the Army, Corps of Engineers (COE), regulates the placement of structures in navigable waters. Also, affected States review EP's and DPP's for consistency with their CZM programs.

2.1A Stipulations

Special stipulations, which are legally binding contractual provisions, often are attached to OCS natural gas and oil leases in response to concerns of the MMS, coastal States, fishing groups, Federal agencies, and others. For example, the stipulations may require the following:

- biological surveys of sensitive seafloor habitats
- special environmental training for operational personnel
- special waste-discharge procedures
- archaeological resource reports
- special operating procedures near military bases or their zones of activity

2.1B Notices to Lessees and Operators (NTL's)

The NTL's quickly notify operators within a particular OCS Region about changes in MMS administrative practices or procedures for complying with rules, regulations, and lease stipulations. Also, NTL's are issued to lessees to clarify requirements that are already established.

2.1C Conditions of Approval

Often, conditions of approval are attached to approved permits, such as applications for permit to drill. These conditions can range from administrative matters (such as the required frequency of reports) to technical or environmental conditions (such as requirements for the disposal of drilling muds). In all cases, they are specific conditions that amplify or explain a requirement in the regulation or lease stipulation.

2.2 Offshore Inspection and Compliance Program

The OCSLA authorizes and requires the MMS to inspect natural gas and oil operations and to schedule annual onsite inspections of each OCS facility subject to any environmental or safety regulation. This annual inspection examines all safety equipment designed to prevent blowouts, fires, spills, or other major accidents. In addition, the OCSLA requires the MMS to conduct periodic inspections without advance notice to the operators of such facilities to ensure compliance with environmental and safety regulations.

The MMS performs these inspections using a national checklist called the Potential Incident of Noncompliance list. This list is a compilation of yes/no questions derived from all regulated safety and environmental requirements. It is divided into the following sections:

- drilling
- environmental
- general
- pipeline
- production
- production measurement
- hydrogen sulfide
- site security requirements

Upon detecting a violation, the MMS issues an Incident of Noncompliance (INC) to the operator and uses one of two main enforcement actions (warning or shut-in), depending on the severity of the violation. If the violation is not severe or threatening, a warning INC is issued. The warning INC must be corrected within a certain amount of time. For violations that threaten the safety of the facility or protection of the environment, a shut-in INC is issued. The shut-in may be for a single component (a portion of the facility) or the entire facility. The violation must be corrected before the operator is allowed to continue the activity in question.

Passage of the Oil Pollution Act of 1990 restored and expanded MMS's authority to impose penalties for regulatory violations that constitute a serious hazard to safety or the environment. Under this augmented authority, the MMS can assess a civil penalty without first providing notice and time for corrective action in cases where a failure to comply with applicable regulations resulted in a threat of serious, irreparable, or immediate harm or damage. In 1991, the MMS used its new civil penalty authority in two cases to initiate and assess fines.

2.3 Environmental Studies Program

The MMS Environmental Studies Program (ESP) supports the OCS Program by providing decisionmakers with information needed to predict, assess, and manage impacts on the OCS and the affected nearshore areas. Studies provide information on the status of the environment (human, marine, and socioeconomic) and the ways and extent that OCS activities can potentially impact the environment and coastal areas. The purpose of the ESP is to ensure that adequate environmental information needed for decisionmaking is available.

From Fiscal Year (FY) 1987 through 1991, more than $114 million have been spent through the ESP on studies. Table 2.3-1 and figure 2.3-1 summarize expenditures throughout that timeframe by OCS Region and topic area, respectively.

Table 2.3-1. Environmental Studies Program, Expenditures by OCS Region, 1987 through 1991

OCS Region	FY 87-91
Alaska	$36,597,790
Atlantic	$8,088,921
Gulf of Mexico	$30,077,353
Pacific	$31,594,202
National Program	$7,793,020
Total	**$114,151,286**

2.4 Coordination with Federal Agencies, State Agencies, and Local Governments

Coordination with other governmental agencies occurs both formally and informally. Formal mechanisms exist through compliance with the many laws that govern the OCS. Leasing and operating activities on the OCS are also subject to the requirements of some 30 Federal laws administered by numerous Federal departments and agencies. Among these laws are the following:

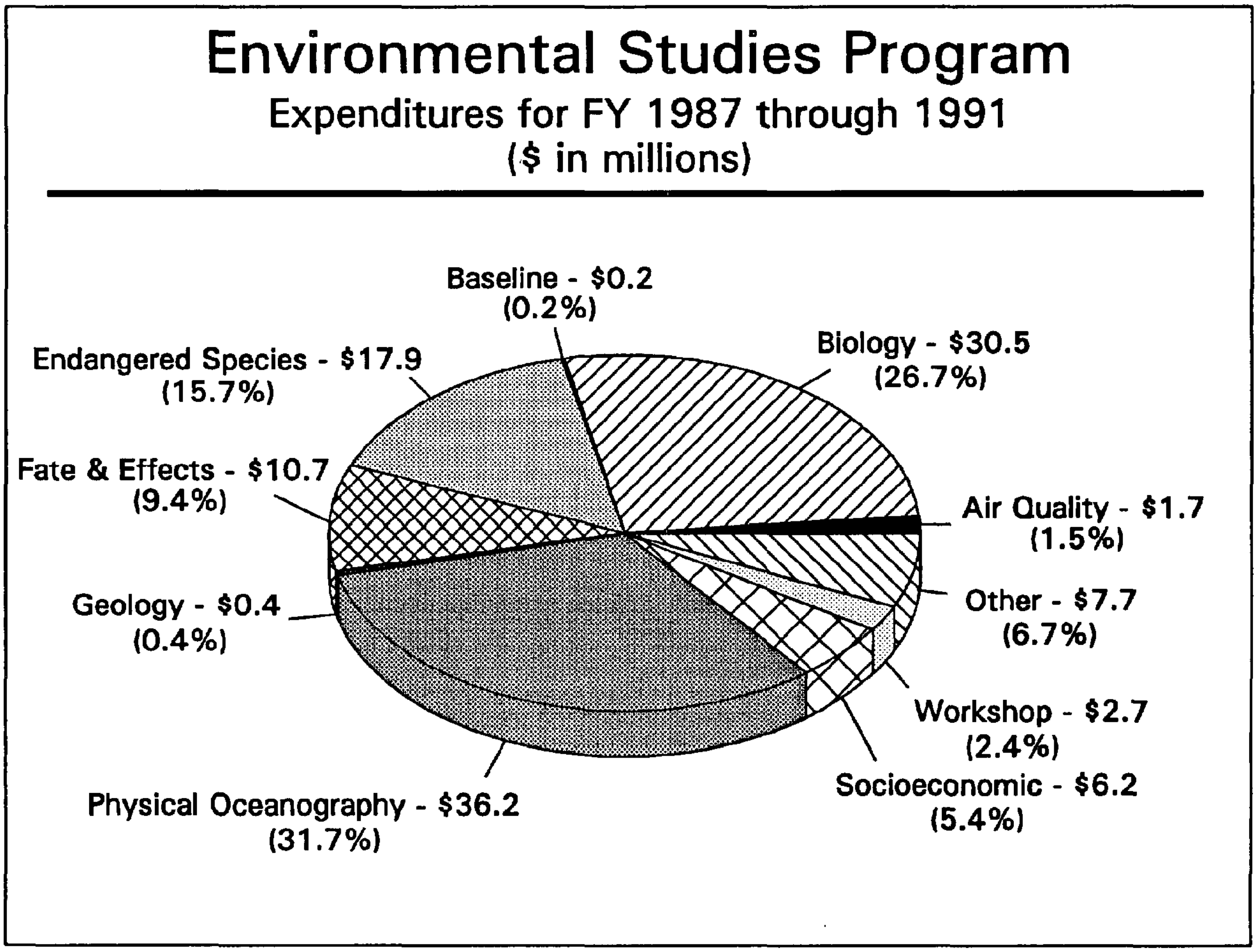


Figure 2.3-1. Breakdown of ESP Expenditures from FY 1987 through 1991

- The National Environmental Policy Act (NEPA) of 1969 establishes requirements for preparing environmental assessments and EIS's for major Federal actions that could significantly affect the quality of the human, marine, or socioeconomic environment.

- The Marine Mammal Protection Act of 1972 provides for protection of marine mammals. It also allows for the incidental, but not intentional, taking of depleted as well as nondepleted marine mammals. The incidental taking of marine mammals is permitted by U.S. citizens under a Letter of Authorization from the appropriate trust agency—the NMFS or the FWS.

- The Coastal Zone Management Act (CZMA) provides for State review of OCS lease sales, EP's, and DPP's that affect the land and water uses and resources of the coastal zone. This Act requires consistency, to the maximum extent practicable, of Federal activities with federally approved CZM plans.

- The Endangered Species Act of 1973 requires that Federal agencies ensure that their actions are not likely to jeopardize the continued existence of any threatened or endangered species.

- The Federal Water Pollution Control Act (commonly known as the Clean Water Act) requires that pollutants generated by OCS operations and discharged into U.S. waters comply with the limitations and restrictions included in a National Pollutant Discharge Elimination System (NPDES) permit.

- The Ports and Waterways Safety Act protects navigational safety.

- The Deepwater Port Act of 1974 requires the USDOT to regulate ports and terminals handling oil for transportation.

- The National Historic Preservation Act requires that the MMS take into account the effects of its leasing and permitting actions on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register of Historic Places. This Act also requires that the Advisory Council on Historic Preservation be given a reasonable opportunity to comment on these undertakings.

- The Clean Air Act Amendments of 1990 establishes jurisdiction of air quality: the USDOI regulates the OCS in the Western and Central GOM, and the EPA regulates the remaining OCS areas.

In addition, the following sections of the OCSLA require coordination with affected States.

- Section 8(g) requires coordination between the USDOI and coastal States whenever a leasing proposal includes lands within 3 miles of State waters.

- Section 18 requires significant participation of affected States, Federal agencies, and the public during the development of a 5-year leasing program.

- Section 19 provides the framework for coordination and consultation with affected States and local governments for each proposed lease sale.

- Section 26 requires the Secretary of the Interior to provide the affected States with indexes and summaries of data to aid them in planning for the onshore impacts of OCS natural gas and oil activities.

To accommodate the different characteristics of the various OCS Regions and areas of the Nation, the MMS implemented the Area Evaluation and Decision Process. This process emphasizes information adequacy, conflict resolution, and responsiveness to local concerns so that program decisions may be uniquely structured to each particular OCS area. The goal of the process is to develop a natural gas and oil resource management program that responds to the needs and concerns of affected States and others, as well as to national energy and economic needs. Increased emphasis is placed on consultation and coordination with interested parties in both the development and implementation of the new OCS Program.

The OCS Advisory Board, established in 1975, provides a formal mechanism for the USDOI to receive advice and recommendations from, and to provide a forum for, coastal States, various Federal agencies, and public and private-sector representatives affected by or interested in OCS minerals development. The following groups compose the OCS Advisory Board: (1) the OCS Policy Committee, (2) the Regional Technical Working Groups (RTWG's), and (3) the Scientific Committee. This three-part structure provides for specialized consideration of the policy, technical, and scientific aspects of the OCS Program.

The OCS Policy Committee advises the Secretary and other officers of the USDOI, through the Director of the MMS, on the USDOI's responsibilities under the OCSLA. These responsibilities include all aspects of leasing, exploration, development, production, and protection of the OCS resources. This committee represents a public forum wherein parties, both public and private, affected by OCS natural gas and oil activities may discuss policy issues with the responsible USDOI officials.

The RTWG's advise the Director of the MMS, through the MMS Regional Directors, on technical matters of regional concern regarding prelease and postlease activities. The roles of the RTWG's range from providing public participation opportunities for discussing technical issues and multiple-use concerns of offshore mineral activities to providing for technical review of the various OCS Program documents. These working groups also recommend future environmental studies. (Note: In 1993, the RTWG for the GOM was rechartered as the GOM Offshore Advisory Committee, and the other RTWG's were abolished.)

Finally, the Scientific Committee advises the Director of the MMS on the feasibility, appropriateness, and scientific value of the ESP. The committee reviews the information produced by the ESP and may recommend changes in the ESP's scope, direction, or emphasis. The membership of the Scientific Committee reflects a balance of scientific and technical disciplines considered important to the management of the ESP.

3.0 Activities Associated with OCS Exploration, Development, and Production

3.1 Geological and Geophysical Investigations

Under the authority of 30 CFR Part 251, the MMS issues permits for surveying mineral resources and for scientific research on the OCS. These activities include geophysical surveys (magnetic, gravity, electrical, sidescan sonar, and seismic) and geological investigations (bottom sampling, coring, and test drilling operations). From 1987 through 1991, the MMS issued a total of 1,281 G&G permits (table 3.1-1).

Table 3.1-1. G&G Exploration Permits Issued by the MMS OCS Regions, 1987 through 1991

				Gulf of Mexico			
Year	Alaska	Atlantic	Pacific	Louisiana	Texas	MAFLA	Yearly Totals
1987	18	2	20	186	52	20	298
1988	13	4	33	172	64	27	313
1989	17	0	0	177	49	6	249
1990	19	1	4	157	64	6	251
1991	7	0	0	109	51	3	170
Total	**74**	**7**	**57**	**801**	**280**	**62**	**1,281**

MAFLA = Mississippi, Alabama, and Florida
Source: Adapted from *Federal Offshore Statistics: 1991* (USDOI, MMS, 1992a)

3.1A Geophysical Surveying

Geophysical survey data provide information on how the physical properties of the earth's upper crust vary vertically and laterally beneath large areas of the OCS.

Gravity surveys measure the earth's gravity field to obtain information on large-scale geological features beneath the OCS (e.g., the presence of large sedimentary basins and the measurement of the average density of a rock formation). Similarly, aerial magnetic surveys measure the earth's magnetic field to detect anomalies that may reveal geological features of economic or other interest.

The seismic reflection method uses the travel time of seismic waves reflected from different geological strata to determine subseafloor geology. Seismic surveys provide more detailed information on the deep distribution of geological boundaries and better resolution of the subsurface geology.

In a typical OCS seismic survey, seismic sources (sound wave generators) are towed behind a ship. A streamer (2 to 3 miles in length) consisting of a cable and arrays of pressure-sensitive hydrophones is towed farther behind the ship. Seismic waves generated by the energy sources reflect off the seafloor and subseafloor strata to the water column where they are detected by the hydrophones. Electrical signals generated by the hydrophones are then transmitted to the survey ship where total travel times and other properties of the seismic signals, such as amplitude and phase, are recorded on magnetic tape.

After initial field data processing aboard ship and more extensive processing onshore, these seismic profiles (vertical cross sections) are interpreted to identify structural features that may act as potential hydrocarbon traps (e.g., sediments that are arched, folded, faulted, or intruded by igneous rocks or by plastic-like sediments such as salt).

Additionally, characteristics of seismic sections are used to identify stratigraphic traps, such as a change in the grain sizes of sediments or where a porous rock containing hydrocarbons thins out horizontally between layers of impermeable rock to block the route of fluids. Seismic sections also can provide information on the thickness of the various sediment strata and on drilling depths to prospective locations in the subbottom.

Other OCS geophysical methods include electrical surveys, which measure natural and artificially induced electrical fields, and sidescan sonar, which maps seafloor physiographic features (e.g., sand waves, rock outcrops, and mud slides) and manmade features (e.g., pipelines, shipwrecks, ordnance, and cables).

3.1B Geological Sampling and Continental Offshore Stratigraphic Test (COST) Wells

Methods to gather physical samples or other bottom data useful for engineering and geological purposes are divided into three types: bottom sampling, core and shallow drilling operations, and deep stratigraphic drilling operations.

Bottom samples are collected by dropping a weighted tube to the ocean floor and recovering it with a wire line. Bottom samples provide the information necessary to determine engineering properties and basic scientific information on the bottom sediments.

Core and shallow drilling operations are conducted to obtain information such as the lithology and geological age of the sediments, engineering properties, and stratigraphic correlations. Currently, pursuant to 30 CFR Part 251, core and shallow test drilling can penetrate no more than 50 feet of consolidated rock or 300 feet of unconsolidated rock into the sea bottom without permits.

Deep stratigraphic drilling operations (or COST wells) use rotary or core drills to penetrate more than 50 feet of consolidated rock or more than 300 feet into unconsolidated sediments. These holes are drilled to obtain regional geological information and exploratory drilling conditions, as opposed to other wells that are drilled to find natural gas and oil. A geological permit for mineral exploration or scientific research is required from the MMS before conducting geological surveys on the OCS. In addition to a geological permit for mineral exploration or scientific research, a drilling permit and a geophysical permit, if necessary, are required for COST wells.

3.2 Exploration Phase

3.2A The Exploration Plan

The OCS lessee bases exploration decisions on the estimated hydrocarbon potential, the availability of rigs, and various economic and environmental factors. The lessee conducts preliminary activities (such as G&G, cultural, and biological surveys) to acquire information needed to prepare an EP—a detailed description of the proposed exploratory activities.

The EP and its supporting documentation are submitted to the MMS for approval (including the oil-spill contingency plan [OSCP]—a description of onshore/offshore support facilities and activities, and an environmental analysis). Upon receipt of the EP, the MMS reviews it for completeness and conformity with regulations. After deeming the EP complete, the MMS has 30 days to approve or disapprove it. If not complete, the EP is returned to the lessee for additional information.

The MMS conducts a technical and environmental review of the EP (in adherence with NEPA regulations). The EP is forwarded to other Federal agencies (including FWS, NMFS, EPA, COE, and the U.S. Coast Guard [USCG]), Governors of affected States, and State agencies for comment (see fig. 3.2-1). A State's review also includes a coastal zone consistency review pursuant to the CZMA—activities described in an approved EP cannot be permitted until State coastal zone consistency concurrence is received or conclusively presumed. Also, the EP is available for public review and comment. By the end of the 30-day period, the MMS must inform the lessee of its decision.

An EP is disapproved for the following reasons: (1) the proposed activities would cause serious harm or damage to life (including marine life), property, minerals, national security or defense, or the marine, coastal, or human environment; and (2) the activities could not be modified to avoid such harm (30 CFR 250.33).

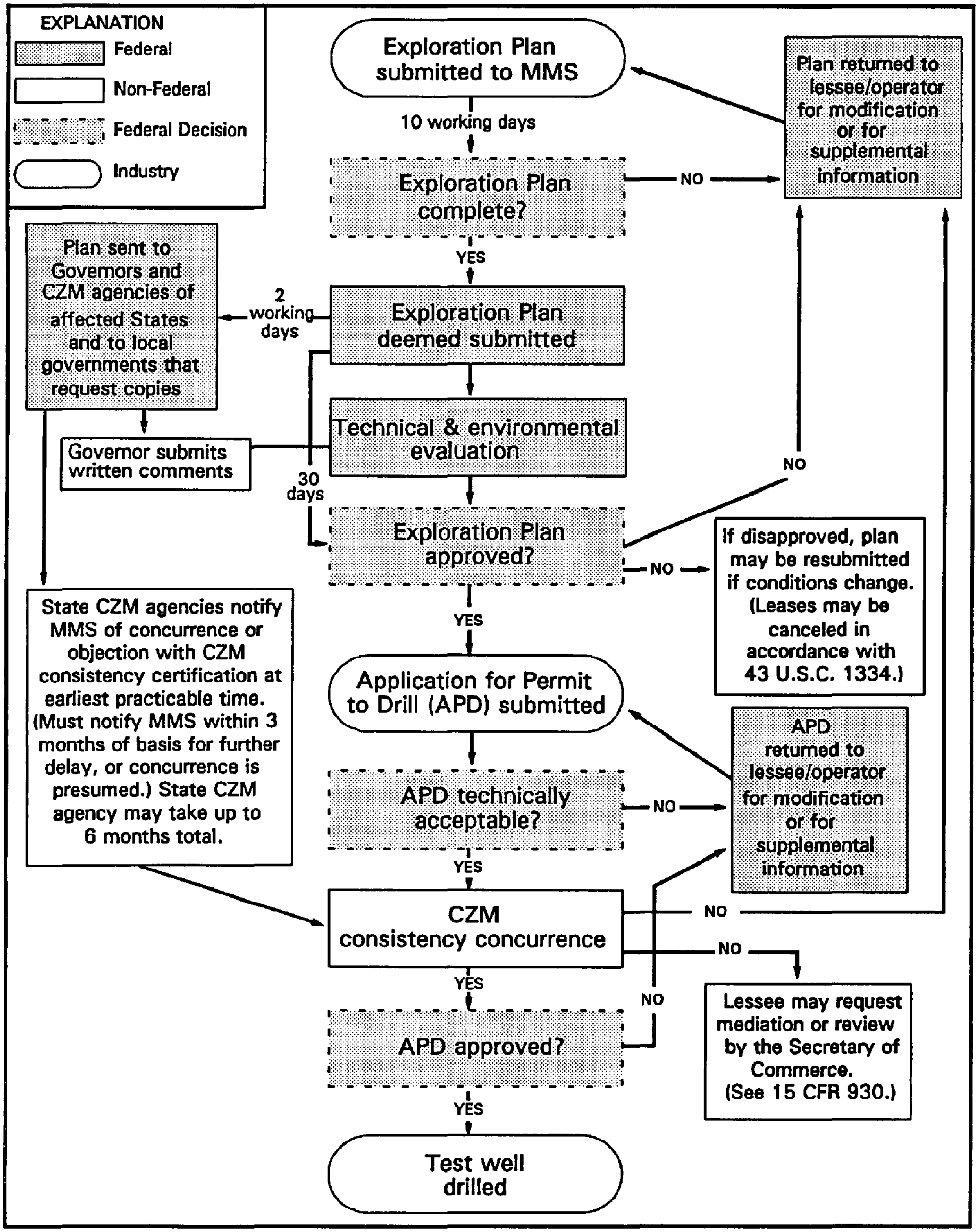


Figure 3.2-1. Exploration Plan Approval Process

If an EP is approved, and before any drilling can commence, the lessee must submit and receive approval for an application for permit to drill (APD) for each well. The APD describes in extensive detail the drilling program, the blowout prevention system, the casing, the cementing, and the drilling mud program. The MMS reviews the APD and frequently attaches to it "conditions of approval" that amplify or explain items in the MMS regulations or that specify procedures that are unique to the well site. The MMS cannot approve the APD until the affected State's coastal zone consistency certification is received or conclusively presumed.

Additionally, the lessee must obtain other Federal permits before drilling begins. Such permits address aids to navigation and certification of mobil offshore drilling units (USCG), siting platforms in navigable waters (COE), and effluent discharges (EPA).

3.2B Rig Emplacement and Artificial Islands

During the exploration phase, the lessee drills one or more wells from a drilling unit to determine whether the lease contains commercial quantities of natural gas or oil. Drilling units used in natural gas and oil operations in the marine environment can generally be classified as follows:

(1) Mobile (Floating) Units

- Drillships are self-propelled vessels with a hole through the hull to allow drilling operations. Some vessels with dynamic positioning capability use thrusters rather than anchors to maintain their position over the drilling site.

- Semisubmersible rigs are towed (some are self-powered) to the drill site, partially submerged, then moored with lines and anchors extending out a mile or slightly more. Some semisubmersibles have dynamic positioning capabilities and do not require anchors.

- Drilling barges are similar to the drillships but are not self-propelled.

(2) Mobile Bottom-Founded Units

- Jack-up rigs have a hull and deck supported by retractable legs. These legs are retracted while the rig is being towed, and then are lowered to rest on the seafloor at the drill site. Once the legs are firmly positioned on the seafloor, the hull is jacked up to the appropriate height, and the deck level is adjusted.

- The submersible drilling unit includes several hull compartments (which are flooded to submerge the unit) and rests on the seafloor.

- Offshore the arctic areas of Alaska, wells are drilled from artificial islands (gravel or ice) or specially designed units (concrete islands and mobile arctic caissons). During the winter, construction materials for artificial islands (usually sand and gravel) are transported over ice and unloaded at the desired location to form the island. During ice-free periods, islands are constructed by dredging material from the sea bottom and delivering it to the construction site by barge or pipeline. An advancement in the island building technique involves pumping sand and gravel into a caisson. This method results in less disturbance to the area where the gravel is collected and a considerable savings in material.

3.2C Drilling

Regardless of the type of drilling rig used, the drilling methods are similar. A drilling derrick is located on the vessel, rig, or island. A drill bit is attached to a hollow drill pipe and rotated by an engine or an electric motor. Rotating the drill bit fractures the subsurface rock into chips (cuttings). As the drilling progresses, drilling fluids are circulated through the drill pipe and bit for the following reasons:

- to remove cuttings from the bottom of the hole
- to lubricate the drill string
- to provide hydrostatic pressure to prevent the flow of formation fluids into the wellbore
- to support and seal the sides of the well

Although in some cases drilling muds and cuttings are barged ashore, usually they are discharged directly from the drilling rig in accordance with limitations in the EPA-issued NPDES permit.

As drilling progresses, the sides of the hole are supported by installing steel casing. Blowout preventers are attached to the casing to close off the well in an emergency situation, such as an unexpected change in well pressure.

Generally, an exploratory well takes from 1 to 6 months to drill. Once exploratory drilling results are known, the lessee generally plugs the well and moves the drilling equipment to a new site.

3.3 Development and Production Phase

3.3A The Development and Production Plan

When a natural gas or oil reservoir is discovered and its extent determined through delineation drilling, the lessee begins the development and production phase of operations. The lessee prepares a DPP—a detailed description of and schedule for proposed development and production activities. The DPP and its supporting documentation (such as an OSCP—a list of proposed environmental safeguards, an assessment of environmental effects, and a report on offshore/onshore support facilities) are submitted to the MMS for approval.

After receiving the DPP, the MMS reviews it for completeness. After the MMS deems the DPP complete, the technical review process begins. If not deemed complete, the DPP is returned to the lessee for additional information.

The MMS conducts a technical and environmental review of the DPP (in adherence with NEPA regulations). The DPP is forwarded to other Federal agencies (including FWS, NMFS, EPA, COE, USCG), Governors of affected States, and State agencies for comment (see fig. 3.3-1). A State's review also includes coastal zone consistency review pursuant to the CZMA—activities described in an approved DPP cannot be permitted until State coastal zone consistency concurrence is received or conclusively presumed. In addition, the DPP is available for public review and comment. If an EIS is not warranted, the MMS must inform the lessee of its decision by the end of a 120-day period. Under the OCSLA, at least one DPP in each frontier area must be declared a major Federal action, and the MMS must prepare an EIS.

A DPP is disapproved if the MMS determines any of the following:

- The lessee failed to demonstrate compliance with applicable Federal laws and regulations

- The State's concurrence has not been conclusively presumed, or the State objected to the consistency certification, and the Secretary of Commerce does not authorize the activity pursuant to the CZMA

- The proposed activities threaten national security or national defense

- Exceptional circumstances exist (30 CFR 250.34), such as exceptional geological conditions or exceptional resource values

As with an EP, when the MMS approves the DPP and before any drilling can commence, the lessee must submit and receive approval for an APD for each well.

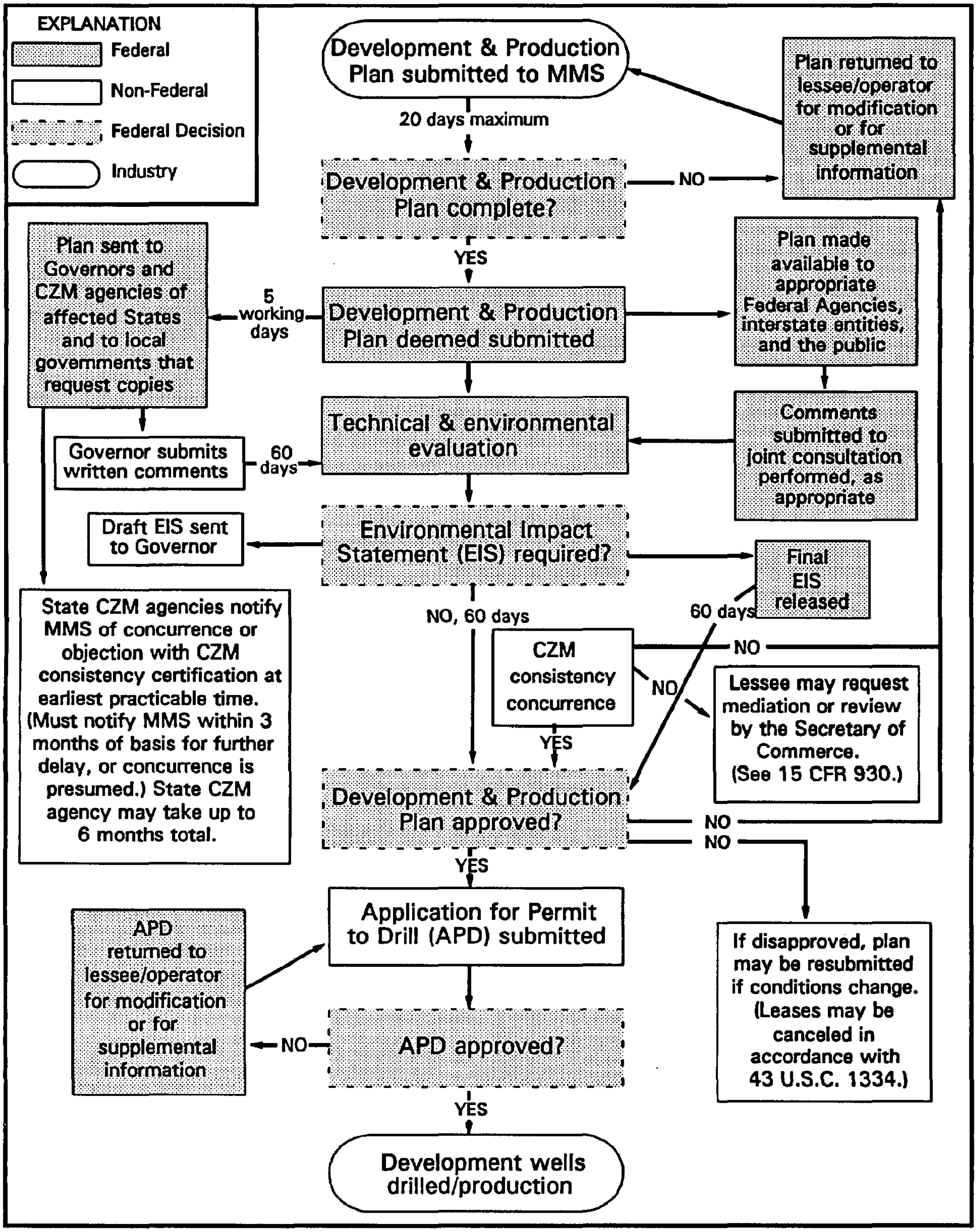


Figure 3.3-1. Development and Production Plan Approval Process

3.3B Platform Emplacement

Development and production activities entail installation of a platform or other production system (e.g., artificial island). Table 3.3-1 shows the number of OCS platforms installed from 1987 through 1991. Usually, offshore development and production activities are conducted on fixed-leg platforms that form an above-water, stable working area. Platforms consist of a deck (or decks)—where drilling, production, and other activities occur—supported by legs and cross members that rest on pilings driven into the sea bottom. Platform legs are constructed onshore, barged to the final location, and sunk into position. Pilings are driven through the legs to secure the base; then the upper working structure is welded on. A production platform accommodates from 1 to 100 production and injection wells and remains in place for the life of the reservoir or field—usually over 30 years.

Table 3.3-1. OCS Production Platform Installations and Removals, 1987 through 1991

	Gulf of Mexico		Pacific	
Year	Installations	Removals	Installations	Removals
1987	119	24	1	0
1988	178	102	0	0
1989	188	100	2*	0
1990	174	107	0	0
1991	143	115	0	0
Total	**802**	**448**	**3**	**0**

Note: No platform installations or removals for the Alaska and Atlantic OCS Regions
*Only the jackets were installed
Source: Adapted from *Federal Offshore Statistics: 1991* (USDOI, MMS, 1992a)

In addition to the platform installation, onshore support facilities must be constructed if they do not already exist. Such facilities include storage yards, pipelines, marine terminals, and processing plants. These facilities also require MMS approval.

3.3C Drilling

Once a platform is installed, several wells are drilled from a single platform to develop the surrounding area. Table 3.3-2 details the drilling status of wells on the OCS from 1987 through 1991. On the OCS, as many as 67 wells have been drilled from a single platform; however, the average number is slightly more than 4—this average is highly influenced by the smaller number of wells per platform in the GOM. The drilling procedures are similar to those discussed above in the section on exploration. Drilling and production involve many activities that could result in undesirable discharges or emissions.

Table 3.3-2 Well Drilling Status, by OCS Area, 1987 through 1991					
OCS Area	**New Well Starts**	**Completions**			**Plugged and Abandoned**
		Oil	**Gas**	**Other**	
1987					
Alaska	2	0	0	1	0
Atlantic	0	0	0	0	0
Central GOM	578	172	112	118	186
Western GOM	132	14	35	34	61
Eastern GOM	4	0	0	0	2
Pacific	43	45	2	8	4
Total	**759**	**231**	**149**	**161**	**253**
1988					
Alaska	1	0	0	1	1
Atlantic	0	0	0	0	0
Central GOM	699	376	139	202	301
Western GOM	270	8	50	54	100
Eastern GOM	1	0	0	1	1
Pacific	32	32	6	7	5
Total	**1003**	**416**	**195**	**265**	**408**
1989					
Alaska	4	0	0	0	3
Atlantic	0	0	0	0	0
Central GOM	670	140	151	138	228
Western GOM	213	5	49	80	70
Eastern GOM	2	0	0	4	0
Pacific	19	18	3	8	5
Total	**908**	**163**	**203**	**230**	**306**
1990					
Alaska	2	0	0	1	6
Atlantic	0	0	0	0	0
Central GOM	728	179	221	199	290
Western GOM	249	2	64	67	110
Eastern GOM	0	0	0	0	0
Pacific	17	29	11	0	2
Total	**996**	**210**	**296**	**267**	**408**
1991					
Alaska	3	0	0	0	3
Atlantic	0	0	0	0	0
Central GOM	478	118	155	166	218
Western GOM	110	2	36	32	53
Eastern GOM	0	0	0	1	0
Pacific	8	13	1	2	3
Total	**599**	**133**	**192**	**201**	**277**

Completions = each tubing string within a well bore.
Other = includes injection, disposal, and water source completions.
Source: Adapted from *Federal Offshore Statistics: 1991* (USDOI, MMS, 1992a)

Some of these activities and the resulting discharges or emissions are discussed below.

- Formation water is produced along with oil during petroleum production. Formation fluid is derived from water that became trapped within sediment pore spaces at the time the sediments were deposited. The amount of this produced water depends on the method of production, field characteristics, and location. As the volume of natural gas and oil production from a reservoir declines, the amount of produced water increases. Disposal of produced water must be in accordance with the limitations of the EPA-issued NPDES permit.

  Naturally occurring radioactive material (NORM) exists in some formation waters. Radioactive elements and their daughter products, such as radium 226 (RA^{226}) and radium 228 (RA^{228}), can be leached from formations by reservoir fluids and transported to the surface with produced water, oil, and gas. Radium isotopes comprise over 90 percent of the total radioactivity in formation waters (Laul et al., 1985; Snavely, 1989).

- Other wastewaters (e.g., sanitary and domestic waste, deck drainage, cooling water, and desalinization-unit discharges) are treated as required and are discharged in accordance with the NPDES permit.

- Air quality emissions from OCS facilities result from combustion, evaporation, or venting of hydrocarbons. Commonly used equipment that generates air emissions are diesel-powered generators and pumps. Operational emissions in the offshore environment are generally low-level, constant, and long-termed. Types of air pollutants include nitrogen oxides (NO_x), carbon monoxide (CO), sulphur oxides (SO_x), total suspended particulates (TSP), and volatile organic compounds (VOC). Ozone is not emitted directly by any source but is formed during a photochemical reaction in the atmosphere involving VOC and NO_x.

- Transportation aspects related to OCS natural gas and oil activities include the conveyance of natural gas and oil to onshore processing facilities by pipeline, shuttle tankers, or barges; and the transport of supplies, services, and personnel by boats and helicopters.

- During the production life of a field, the lessee conducts well workover or repair operations to maintain a high production level. Such operations usually require MMS approval.

Throughout the drilling and production phases, the MMS inspects the operations to ensure compliance with regulations. This inspection further ensures operational safety and pollution prevention. Also, the MMS requires drilling personnel involved with well control to attend training given at MMS-certified schools.

3.3D Pipeline Construction

Installation of subsea pipelines is a short-term (days) activity for a particular location but may cover extensive space (miles). There are several types of vessels used for offshore pipelaying operations. The most common is the pipelaying barge on which the pipe sections are welded together and laid in a continuous string from the center or side of the barge. Newer variations to the pipelaying barge include semisubmersible vessels, ship-shaped vessels, and reel barges (which use reels of pipe rather than welded, straight sections). Pipelines are placed in trenches to protect them from the forces of water currents and wave action in shallow water and to minimize impacts on fish trawling activities. In the surf and beach zone, pipelines are pulled into a prepared trench and covered to restore the area to its original configuration. Pipelines coming ashore and crossing wetlands use specialized technologies including single ditch, double ditch, and flotation canal methods.

3.3E Platform Removal

Once platforms are no longer useful, they are removed, the wells are plugged, and the surrounding seafloor is cleared of obstructions. Current technology available for platform removal includes bulk explosives, shaped explosive charges, mechanical cutters, and underwater arc cutters. The use of bulk explosive charges has been the most common procedure (about 90 percent). Under this method, the pilings of the platform are blown off below the seafloor, and the platform is loaded onto barges for transportation away from the site.

3.4 Non-Routine Events

For purposes of this report, an OCS-related oil spill is an accidental release of crude oil or condensate originating from an OCS-related activity.

All crude oils contain a combination of hydrocarbon and nonhydrocarbon components; the relative proportions of these components determine the oil's toxicity. The hydrocarbon components usually make up the major portion of the crude oil—some crude oils are more than 95 percent hydrocarbons (Kallio, 1976; National Research Council [NRC], 1985). The principal classes of hydrocarbons found in crude oil are alkanes, cycloalkanes, and aromatic hydrocarbons. Nonhydrocarbon components of crude oil include sulfur, nitrogen, oxygen, and a variety of trace metals.

The chemical and physical properties of spilled oil change with time. The rate of change depends on the initial chemical composition of the oil and on "weathering" or aging. Generally, the longer spilled oil is weathered, the fewer ecologically damaging constituents it will contain. Weathering tends to reduce the toxicity of spilled oil because many of its acutely toxic components are lost through evaporation, dissolution, or degradation from photo-oxidation and microbial activity. The impacts caused by heavily weathered oil (tars and resins) are generally related to physical rather than chemical properties.

With or without fires, oil spills (including diesel fuels) and blowouts (uncontrolled flows of gas, oil, or other well fluids into the atmosphere) emit pollutants. These accidental emissions can include hydrocarbons, hydrogen sulfide, NO_x, CO, SO_x, and TSP. Table 3.4-1 enumerates all the Federal oil spills from OCS facilities from 1987 through 1991 that were greater than 1 barrel (bbl), and table 3.4-2 lists oil spills of 1,000 bbl or greater from facilities on Federal OCS leases from 1987 through 1991.

Table 3.4-1. Number and Volume of Offshore Oil Spills Greater Than 1 bbl from Federal OCS Lease Facilities and Operations, 1987 through 1991

Gulf of Mexico OCS				Pacific OCS				Total OCS Spillage (bbl)
Year	Number of Spills >1-50	Number of Spills >50	Total Spillage (bbl)	Year	Number of Spills >1-50	Number of Spills >50	Total Spillage (bbl)	
1987	35	1	231	1987	3	0	12	243
1988	30	3	15,971	1988	2	0	3	15,979[1]
1989	24	1	476	1989	3	0	8	484
1990	35	3	19,307	1990	1	1	101	19,408
1991	33	1	570	1991	5	0	63	633
Total	**157**	**9**	**36,555**	**Total**	**14**	**1**	**187**	**36,747**

[1]This total includes 1 spill of 5 bbl on the Alaska OCS.
Source: Adapted from *Federal Offshore Statistics: 1992* (USDOI, MMS, 1993a).

Table 3.4-2. Offshore Oil Spills of 1,000 bbl or Greater from Federal OCS Lease Facilities and Operations, 1987 through 1991

Year	Location	Cause of Accident	Spillage (bbl)
1988	Galveston Block A-2	Anchor damage to pipeline	15,576
1990	Ship Shoal Block 281	Anchor damage to pipeline	14,423
1990	Eugene Island Block 314	Trawl damage to pipeline valve	4,569

Source: Adapted from *Federal Offshore Statistics: 1992* (USDOI, MMS, 1993a).

4.0 Observed Effects of the OCS Program

4.1 Gulf of Mexico Region

The Gulf of Mexico (GOM) Region is divided into three planning areas: Western, Central, and Eastern GOM (fig. 4.1-1). Figures 4.1-2 through 4.1-14 illustrate the various tracts and features of these planning areas. More detailed information relating to the OCS Program covering the period from 1987 through 1991 can be found in *Gulf of Mexico Update (July 1986 - April 1988)* (USDOI, MMS, 1988b), *Gulf of Mexico Update (May 1988 - July 1989)* (Gould, 1989), and *Gulf of Mexico Update: August 1989 - June 1992)* (Gächter, 1992). There were 12 OCS lease sales held for the GOM between 1987 and 1991: 5 in the Western GOM, 6 in the Central GOM, and 1 in the Eastern GOM (table 4.1-1).

Table 4.1-1. Gulf of Mexico OCS Lease Sales, 1987 through 1991

		Sale Offering			Bids Made			Leases Issued	
Sale	**Date**	**Area**	**Tracts**	**Acres**	**Number**	**Tracts**	**Acres**	**Tracts**	**Acres**
1987									
110	4/22/87	Central GOM	5,881	31,818,472	385	313	1,636,330	293	1,539,610
112	8/12/87	Western GOM	5,045	27,943,606	519	367	2,021,096	347	1,908,199
1988									
S/S*	2/24/88	Central GOM	51	593,971	20	14	142,685	14	142,685
113	3/30/88	Central GOM	6,229	33,580,661	931	684	3,523,205	662	3,416,759
115	8/31/88	Western GOM	5,053	27,911,790	370	270	1,499,164	255	1,412,764
116-1	11/16/88	Eastern GOM	8,149	46,417,392	135	115	657,349	115	657,348
1989									
118	3/15/89	Central GOM	5,970	32,123,675	821	591	2,972,567	574	2,892,535
122	8/23/89	Western GOM	5,043	27,973,997	676	488	2,759,424	475	2,688,394
1990									
123	3/21/90	Central GOM	5,667	30,493,461	840	538	2,671,597	525	2,604,259
125	8/22/90	Western GOM	4,792	26,295,305	465	307	1,699,507	300	1,659,187
1991									
131	3/27/91	Central GOM	5,420	29,127,324	637	464	2,265,799	456	2,224,284
135	8/21/91	Western GOM	4,287	23,616,034	182	142	792,546	135	753,059

*OCS Salt and Sulphur Sale
Source: Adapted from *Federal Offshore Statistics: 1991* (USDOI, MMS, 1992a)

During the 5 years covered by this report, the following OCS-related prelease and postlease activities and associated discharges occurred in the Gulf of Mexico Region.

- 1,133 prelease G&G permits were issued
- 2,209 exploration wells were drilled
- 2,005 development wells were drilled
- 802 OCS platforms were installed
- 448 OCS platforms were removed
- 3,665 miles of OCS pipeline were installed
- 5.8 million barrels (MMbbl) of drilling muds were generated annually
- 1.8 MMbbl of drill cuttings were generated annually
- 0.15 MMbbl of produced sands were generated annually
- 660 MMbbl of produced waters were generated and discharged annually
- about 1.47 billion barrels (Bbbl) of crude oil and condensate were produced
- over 22.5 trillion cubic feet of natural gas were produced
- 163 small spills ($>$1-999 bbl) resulted in a total oil spillage of 1,987 bbl, and 3 large pipeline spills ($\geq$1,000 bbl) resulted in a total oil spillage of 34,568 bbl

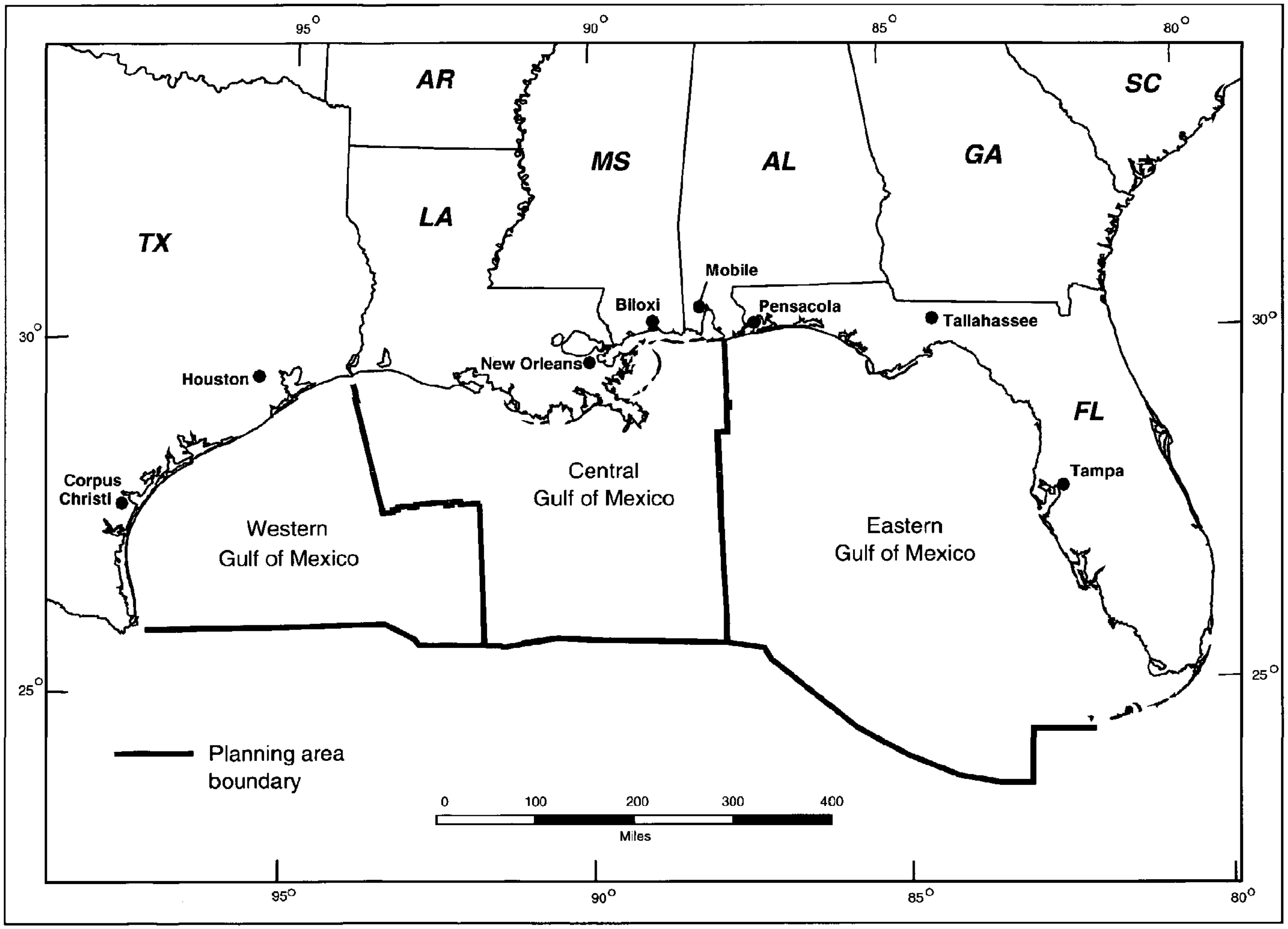
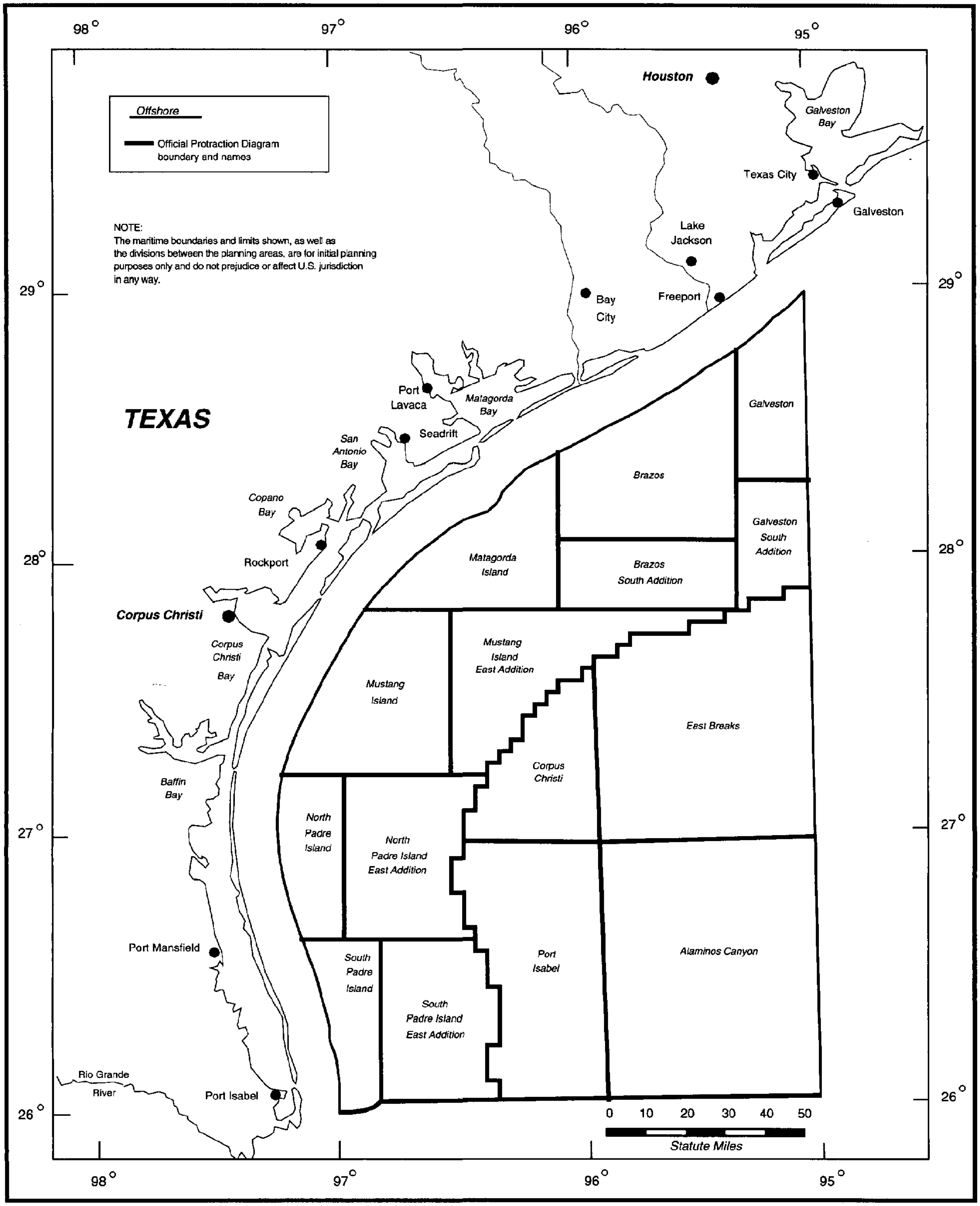
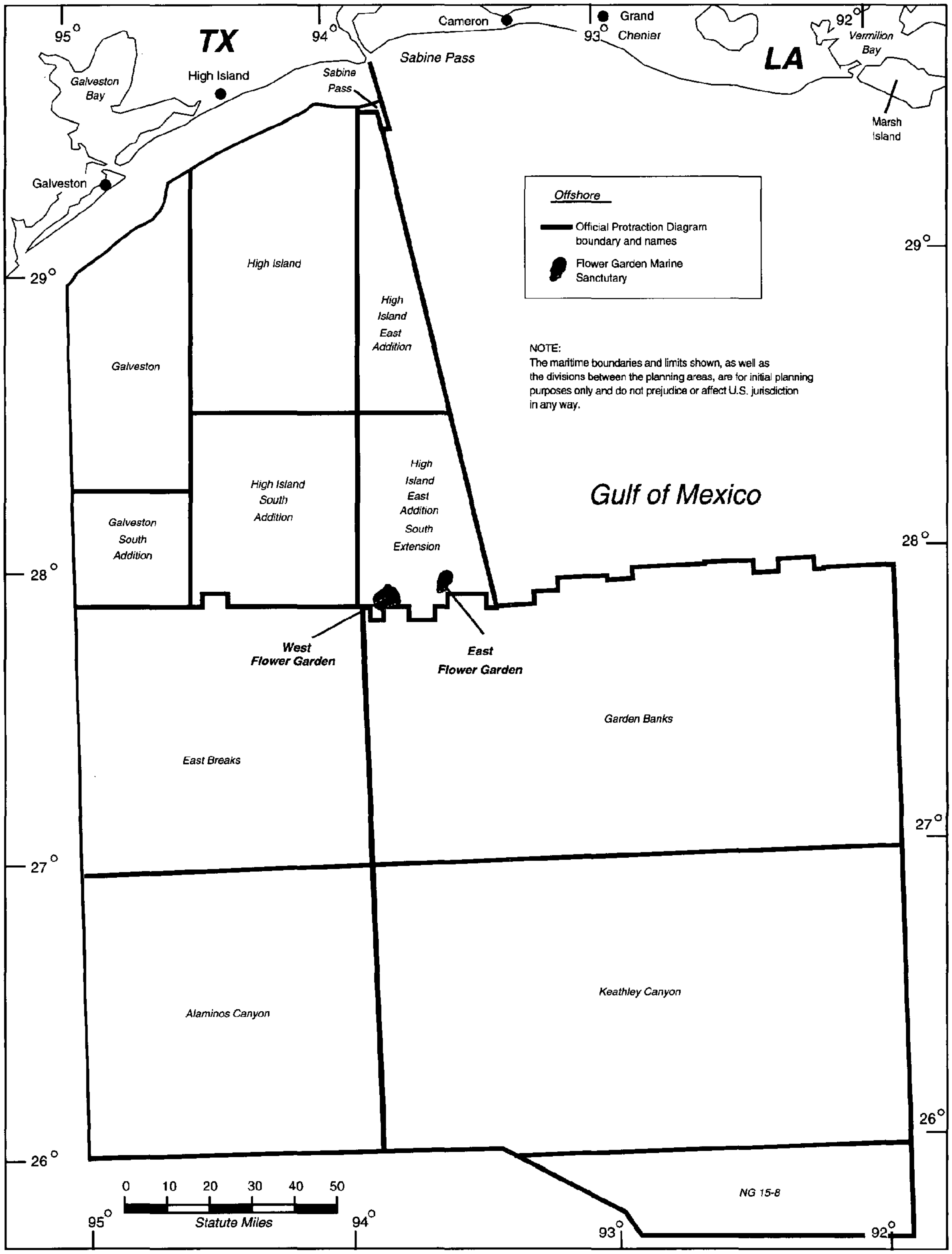


Figure 4.1-1. Gulf of Mexico OCS Planning Areas



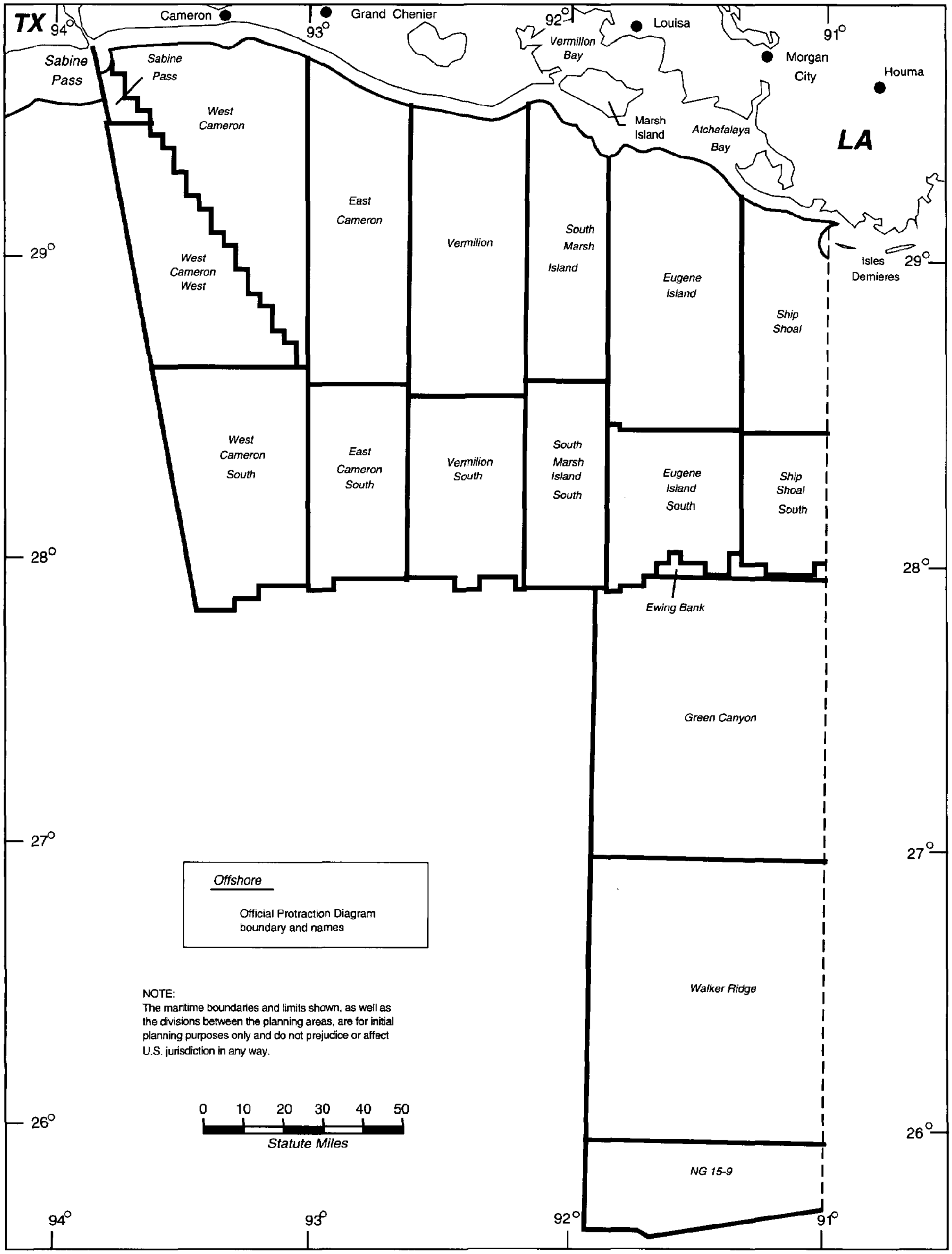
Source: Adapted from MMS Gulf of Mexico source maps, 1994.

Figure 4.1-2. Western Gulf of Mexico (Western Portion) Official Protraction Diagrams



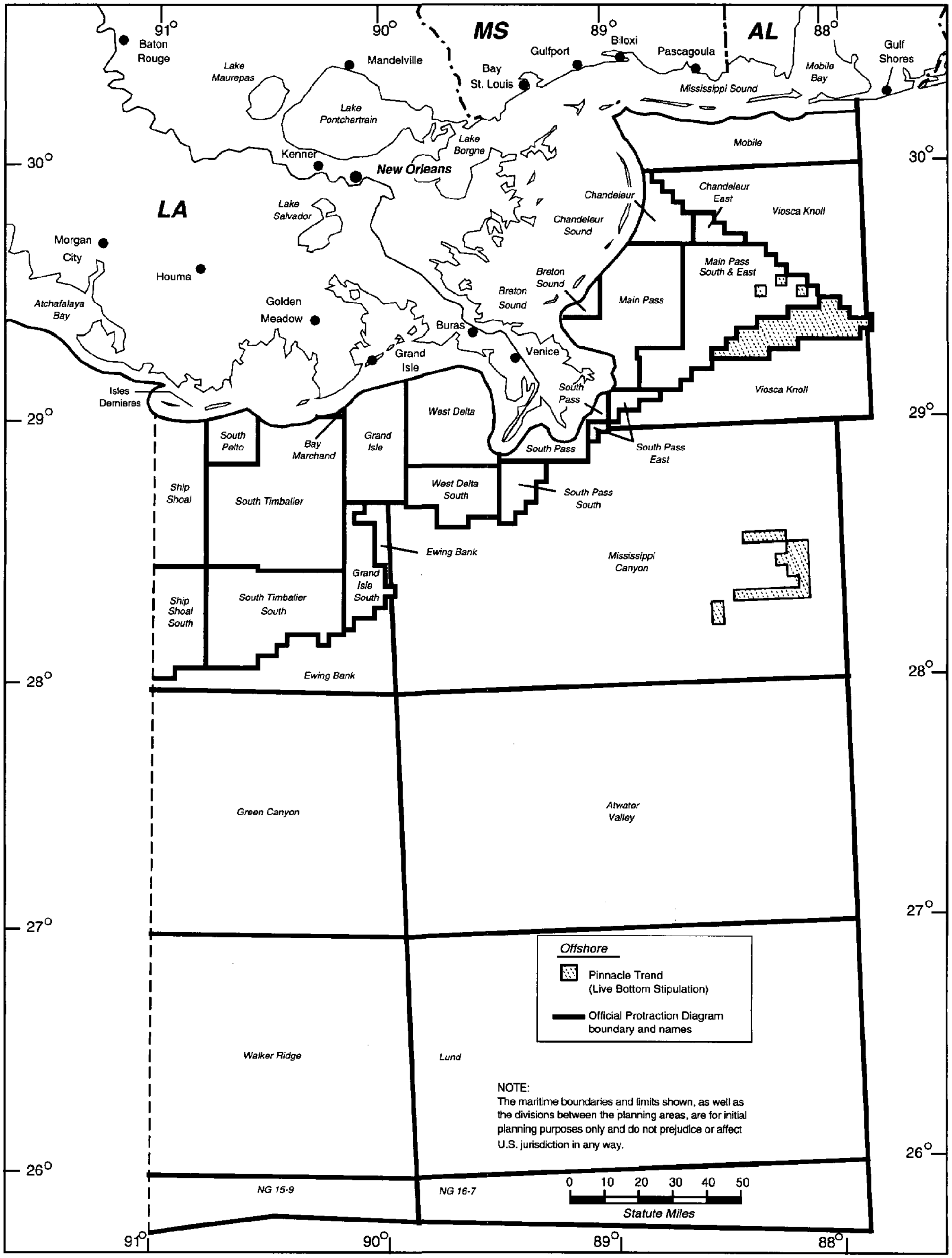
Source: Adapted from MMS Gulf of Mexico source maps, 1994.

Figure 4.1-3. Western Gulf of Mexico (Eastern Portion) Official Protraction Diagrams



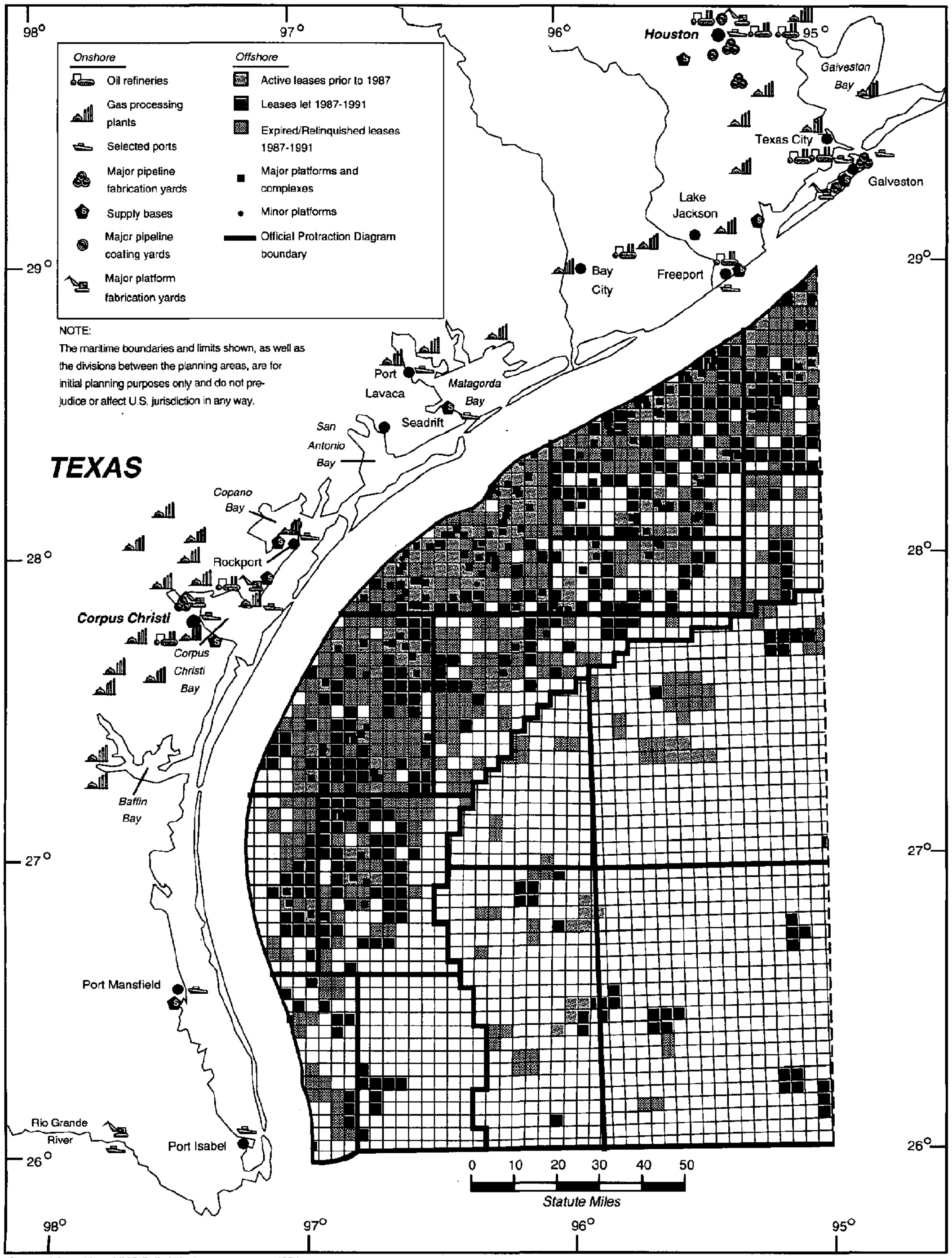
Source: Adapted from MMS Gulf of Mexico source maps, 1994.

Figure 4.1-4. Central Gulf of Mexico (Western Portion) Official Protraction Diagrams



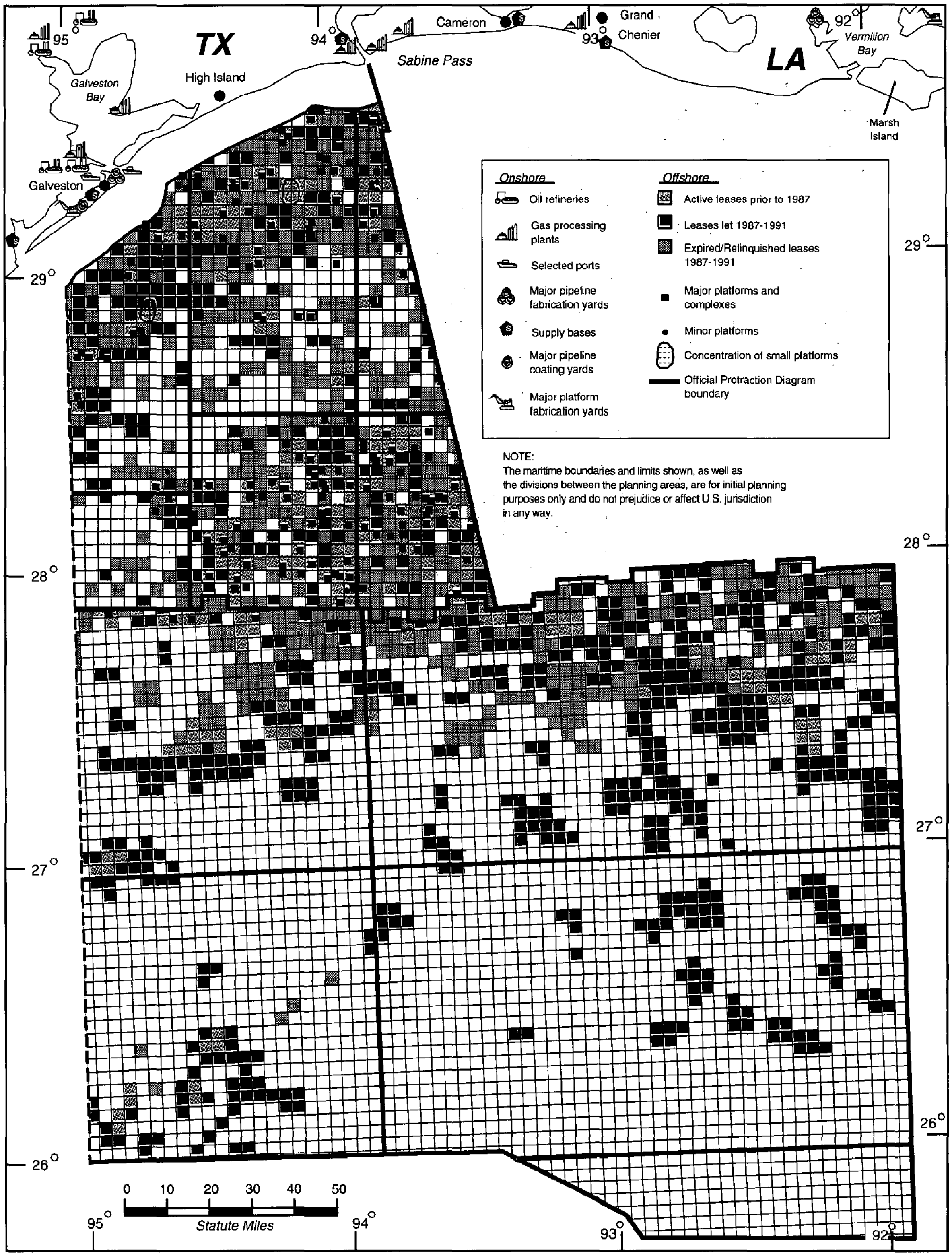
Source: Adapted from MMS Gulf of Mexico source maps, 1994.

Figure 4.1-5. Central Gulf of Mexico (Eastern Portion) Official Protraction Diagrams



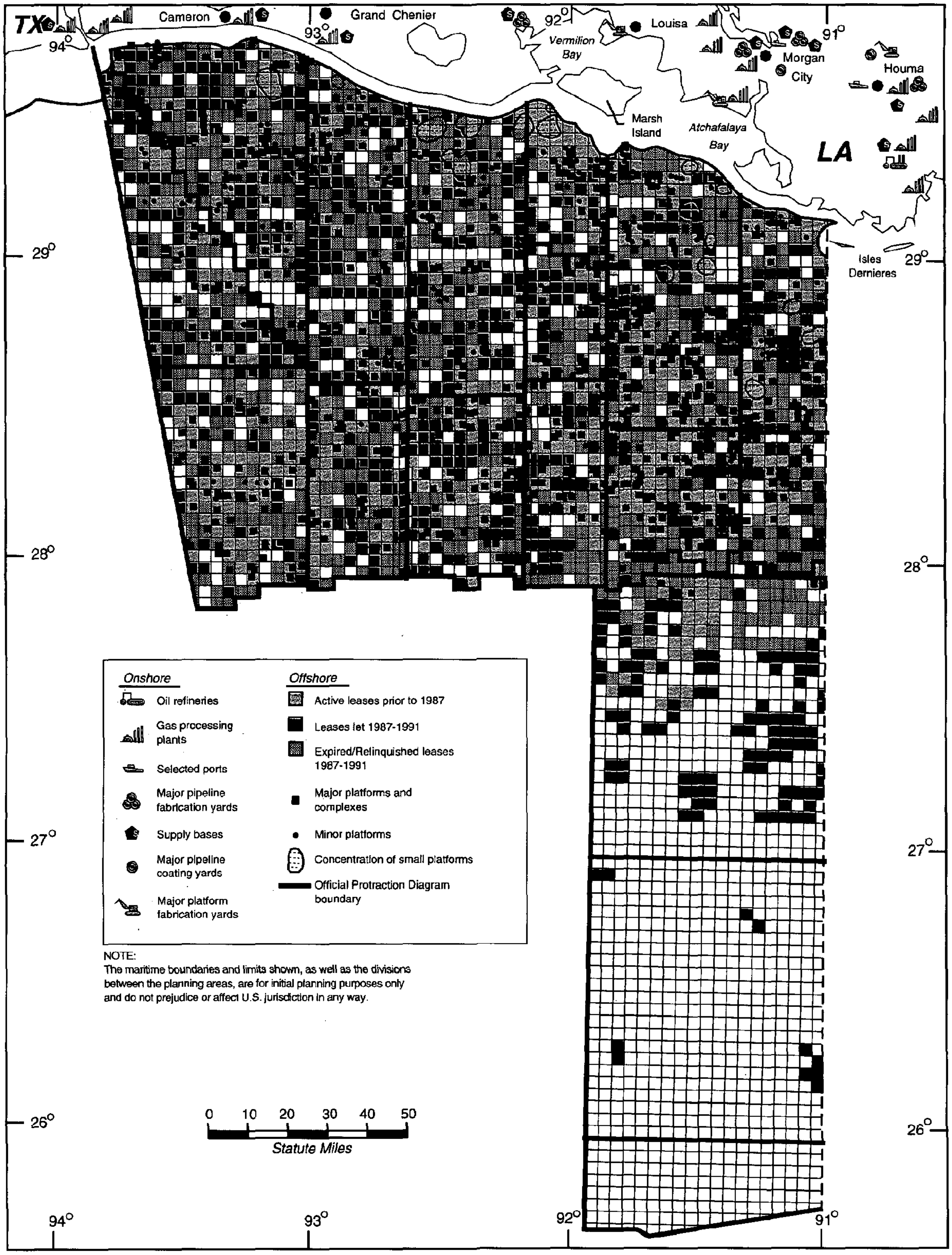
Source: Adapted from MMS Gulf of Mexico source maps. 1994.

Figure 4.1-6. Western Gulf of Mexico (Western Portion), Status of Leases



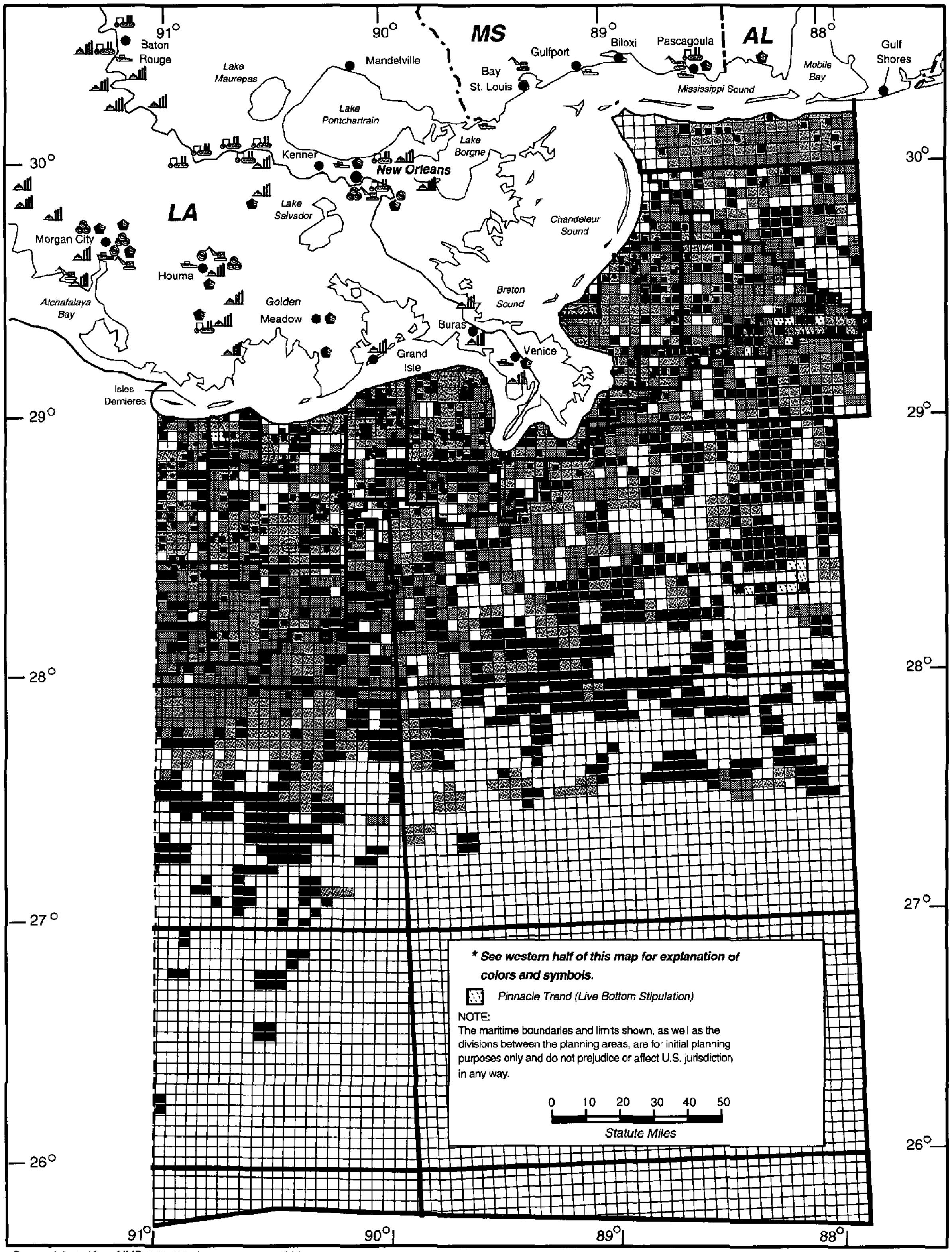
Source: Adapted from MMS Gulf of Mexico source maps, 1994.

Figure 4.1-7. Western Gulf of Mexico (Eastern Portion), Status of Leases



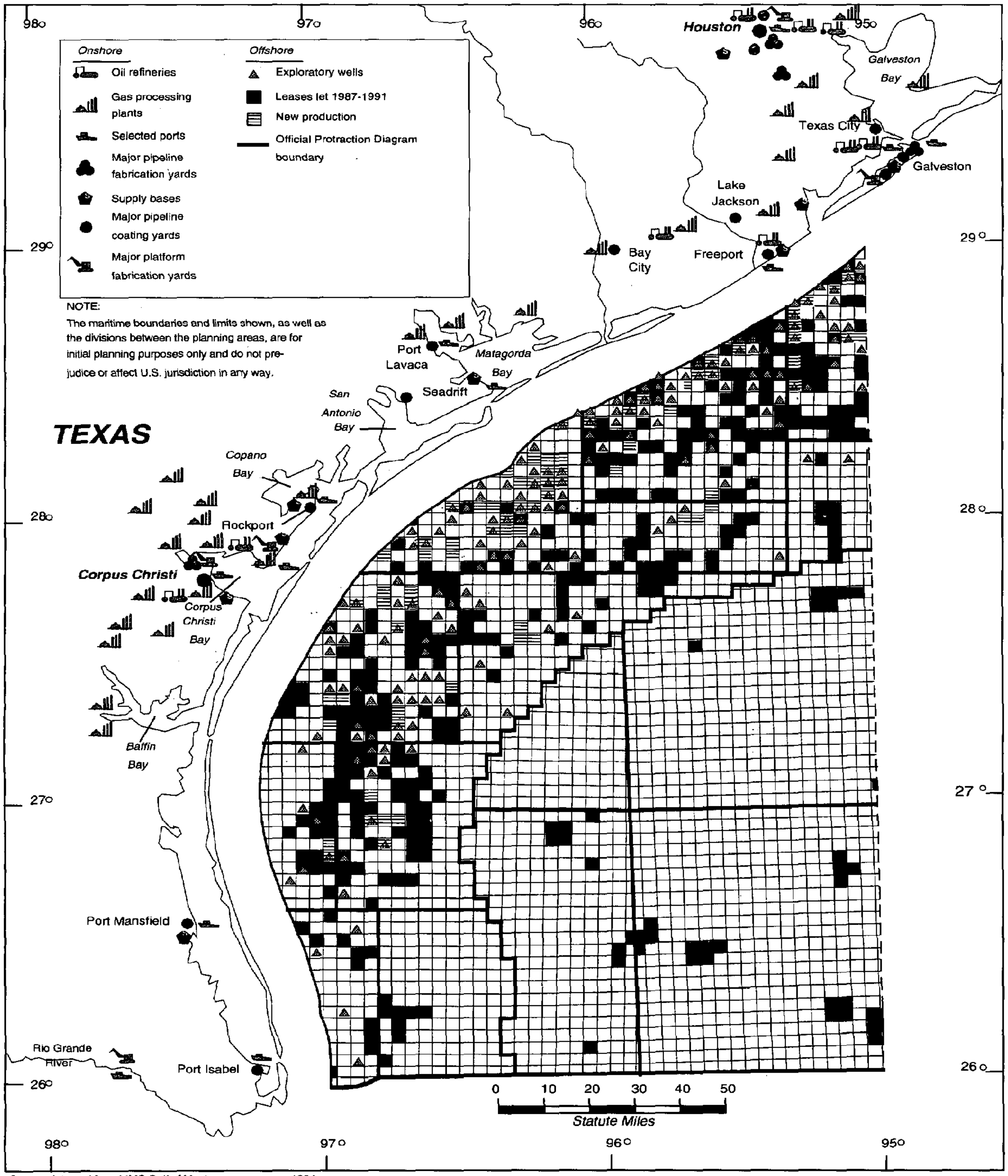
Source: Adapted from MMS Gulf of Mexico source maps, 1994.

Figure 4.1-8. Central Gulf of Mexico (Western Portion), Status of Leases



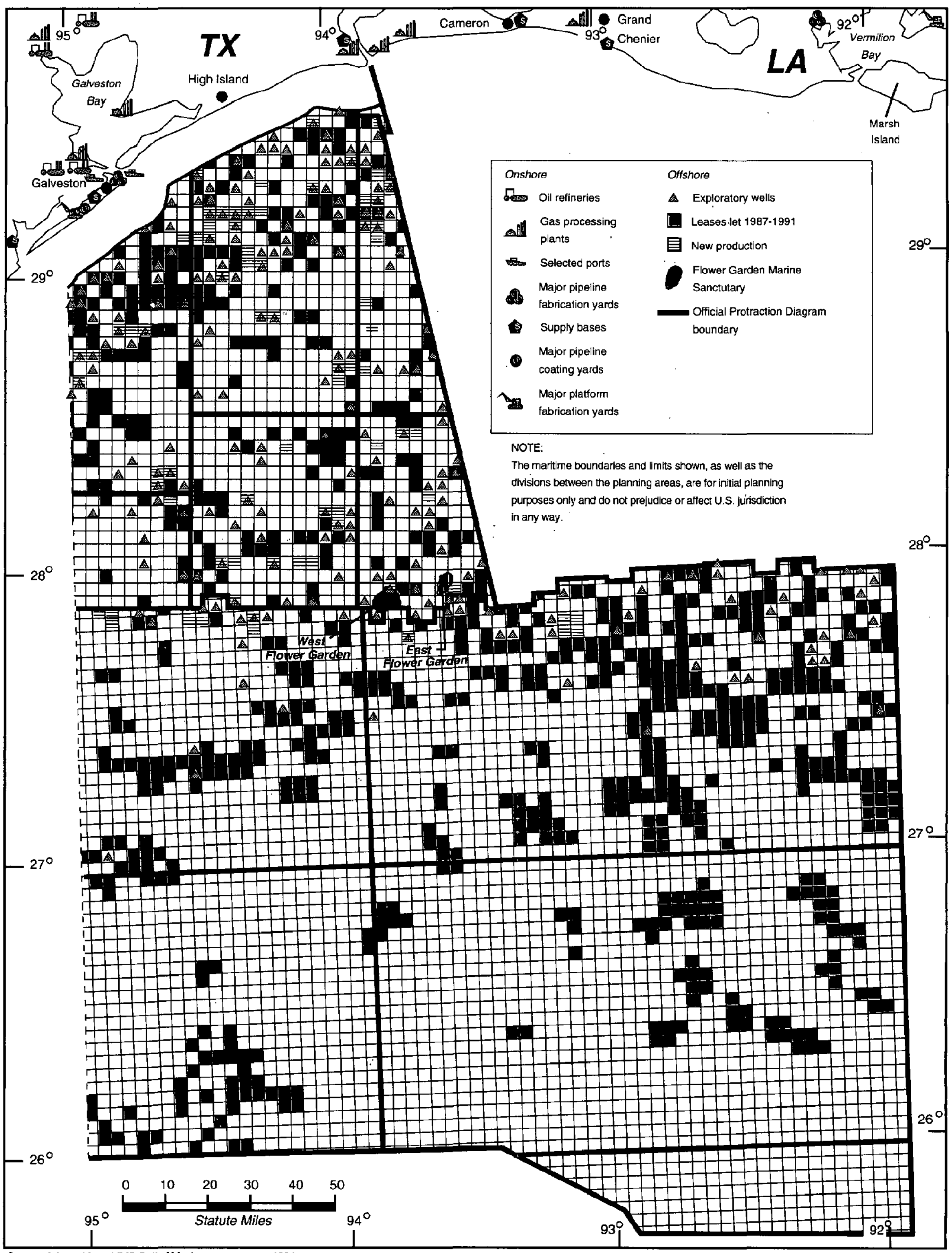
Source: Adapted from MMS Gulf of Mexico source maps, 1994.

Figure 4.1-9. Central Gulf of Mexico (Eastern Portion), Status of Leases



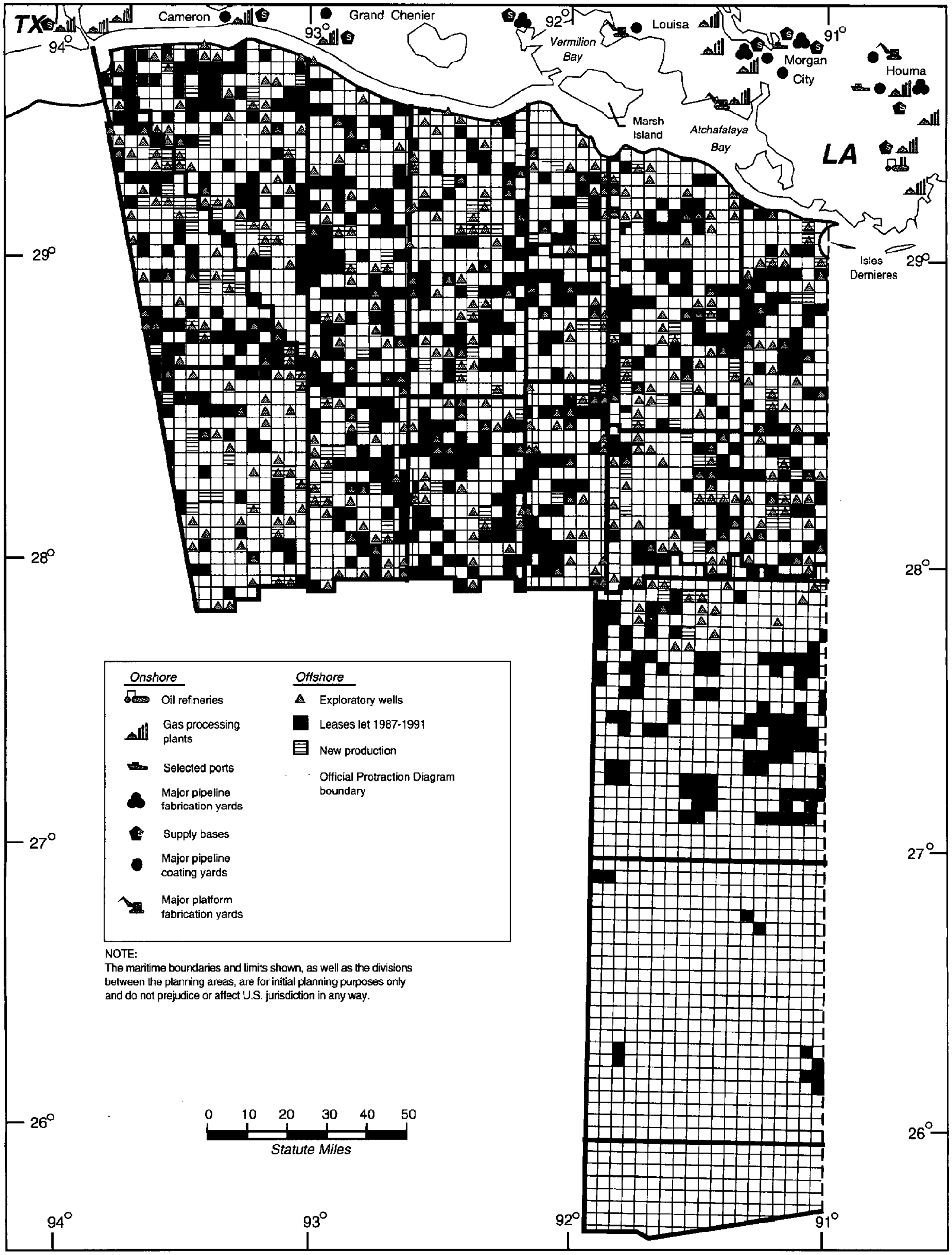
Source: Adapted from MMS Gulf of Mexico source maps, 1994.

Figure 4.1-10. Western Gulf of Mexico (Western Portion), Exploration and Production Activities, 1987 through 1991



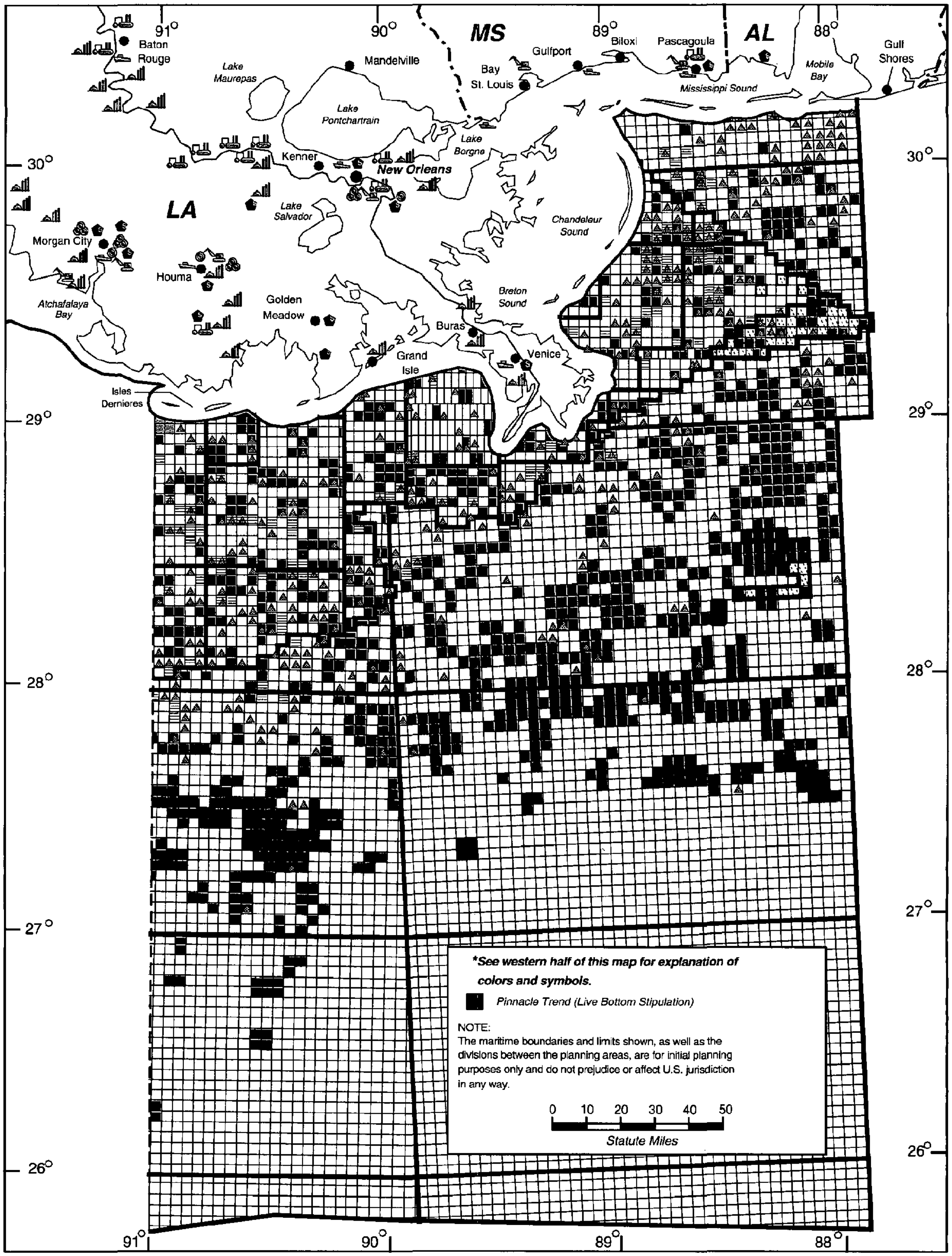
Source: Adapted from MMS Gulf of Mexico source maps, 1994.

Figure 4.1-11. Western Gulf of Mexico (Eastern Portion), Exploration and Production Activities, 1987 through 1991



Source: Adapted from MMS Gulf of Mexico source maps, 1994.

Figure 4.1-12. Central Gulf of Mexico (Western Portion), Exploration and Production Activities, 1987 through 1991



Source: Adapted from MMS Gulf of Mexico source maps, 1994.

Figure 4.1-13. Central Gulf of Mexico (Eastern Portion), Exploration and Production Activities, 1987 through 1991

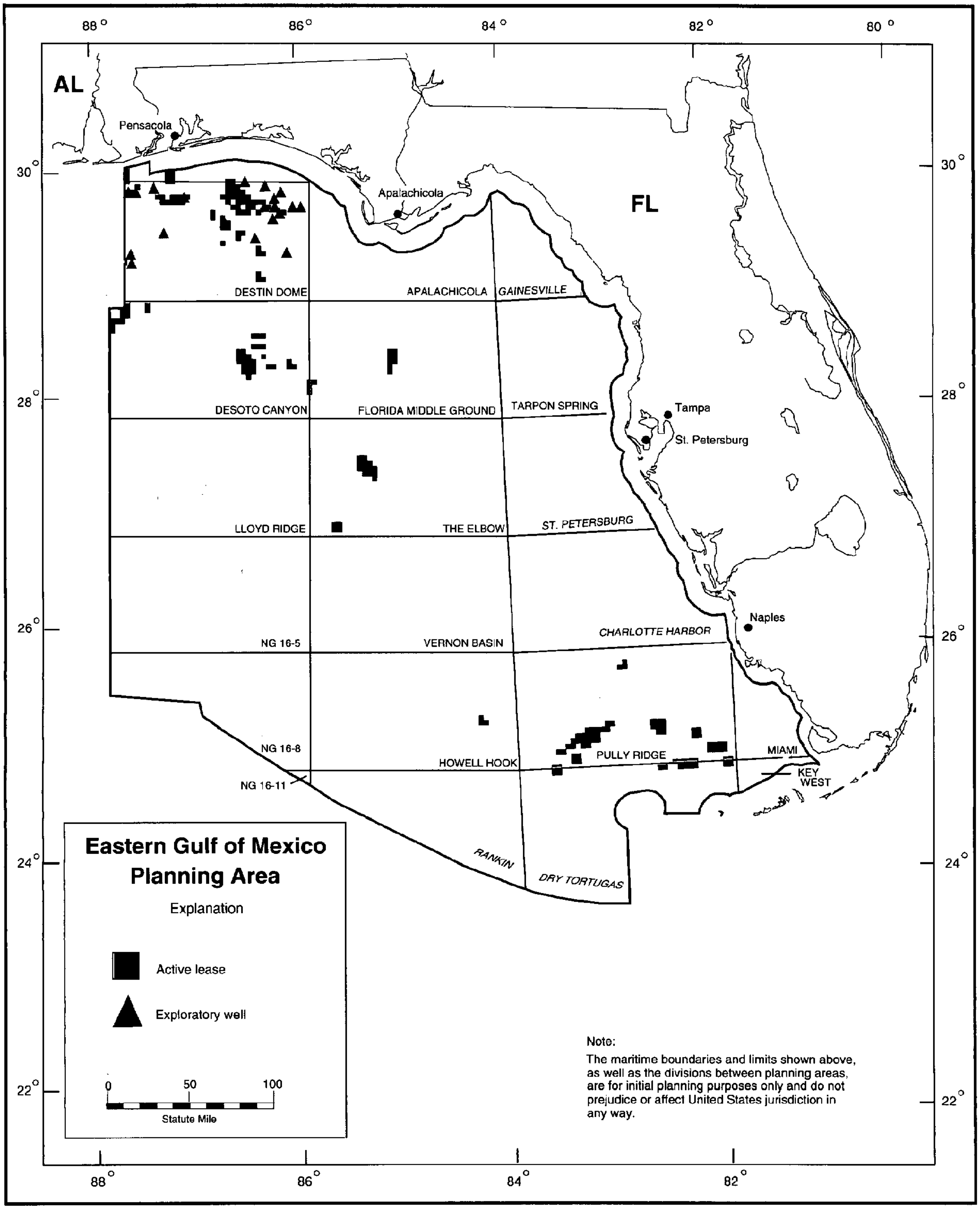


Figure 4.1-14. Eastern Gulf of Mexico, Status of Leases and Exploration Activities, 1987 through 1991

4.1A Physical Environment

4.1A1 Water Quality

From 1987 through 1991, the GOM Region issued 1,133 OCS G&G permits, as shown in the table 4.1-2.

Table 4.1-2. OCS G&G Permits Issued by the Gulf of Mexico Region, 1987 through 1991

Year	Gulf of Mexico			Yearly Totals
	Louisiana	Texas	MAFLA[1]	
1987	186	52	20	**258**
1988	172	64	27	**263**
1989	177	49	6	**222**
1990	157	64	6	**227**
1991	109	51	3	**163**
Total	**801**	**280**	**62**	**1,133**

[1]MAFLA - Mississippi, Alabama, and Florida
Source: Adapted from *Federal Offshore Statistics: 1991* (USDOI, MMS, 1992a)

Effects of OCS Geological Sampling: Geological sampling is done during prelease, postlease, and deep stratigraphic operations. Prelease piston coring operations, averaging about 5-11 per year, are conducted at depths less than 6 meters (m) and are spaced every 4-10 kilometers (km). Postlease cores are only taken as part of the shallow hazards survey requirement. Deep stratigraphic testing is rarely done in the GOM.

Geological sampling activities alter and degrade water quality around the immediate sampling site. Bottom sampling and shallow coring cause very minor sediment suspension with an associated, temporary, localized increase in turbidity. However, deep stratigraphic testing, being similar to rotary drilling of exploratory wells, results in the discharge of drilling muds and cuttings. As a result, the receiving waters experience increased amounts of suspended solids and trace metals. In general, dilution, dispersion, and settling limit the effects of drill muds and cuttings on water quality to the immediate vicinity of the discharge. These effects usually are not detected beyond 1,000-2,000 m from the discharge source (NRC, 1983; Houghton et al., 1980; Ayers et al., 1980a, b).

Conclusion: The studies mentioned above lead to the conclusion that any effects from the limited number of shallow coring operations conducted in the GOM were temporary and confined in spatial extent.

Effects of OCS Support Vessel Traffic: Based on the number of OCS facilities operating in the GOM from 1987 through 1991, an estimated 52,000 OCS-related service vessel trips and 440 OCS-related barge trips occurred annually in the GOM. Existing navigational channels were used, and no new channels were dredged for OCS support vessels. According to Louisiana historical data (Turner and Cahoon, 1987), the bulk of OCS support vessel trips during this period took place in the Calcasieu Ship Channel to Cameron, the Atchafalaya River waterway to Morgan City, Freshwater Bayou to Intracoastal City, and the Mississippi River passes (particularly the reach to Venice). On average, OCS support vessel traffic represented approximately 12 percent of the traffic using these navigational channels. Additionally, about 18 percent of the barge traffic carrying oil between terminals or to refineries during this time was OCS-related.

Support vessels degrade coastal water quality by the following means:

- discharging bilge and ballast water, and treated sanitary and domestic wastes
- increasing turbidity through bank erosion and maintenance dredging of access channels
- spilling oil

Operational discharges (e.g., bilge and ballast waters) from OCS service vessels traversing the coastal zone, although diluted and discharged slowly over large lengths of the channel, do contribute to some degradation of water quality in some navigational channels used. Based on an average of 0.5 bbl/hr/vessel trip (NERBC, 1976), an estimated 21,400 bbl of bilge waters were discharged annually into navigational channels from service vessel traffic during the period from 1987 through 1991.

From 1987 through 1991, it is estimated that OCS-related vessel traffic caused approximately 147 hectares (ha) of sediments to erode annually from confined canals, bayous, and river banks. This amount is based on the level of estimated OCS-related vessel traffic in the GOM and on a rate of 1.5 m/yr of erosional widening of channels (based on information in Johnson and Gosselink, 1982). The volume of material dredged as part of maintenance operations was not known. Most Louisiana major navigational channels were dredged every other year during 1987-1991 to maintain water depth. Both channel bank erosion and dredging resulted in some localized, short-term increases in turbidity and resuspension of contaminants in disturbed sediments.

Conclusion: Considering the possible acute effects of sedimentation from bank erosion, bilge water discharge, and operational discharges, there were only minor, localized, long-term changes in water quality characteristics in the confined portions of the navigational channels used by OCS-associated vessel traffic in the GOM during this time.

Effects of Offshore Discharge of Routine OCS Operational Wastes: The main operational wastes generated by OCS exploration and production are produced water, drilling fluids and cuttings, ballast water, and storage displacement water. Other wastes generated by OCS activities are as follows:

(1) Drilling
- waste chemicals
- fracturing and acidifying fluids
- well completion and workover fluids

(2) Production
- produced sands
- deck drainage
- miscellaneous well fluids (cement, blowout preventor fluid)

(3) Other sources
- sanitary and domestic wastes
- gas and oil processing wastes
- miscellaneous minor discharges

In general, oily wastes (produced waters and sands) and processing fluids are collected into one drainage system and then sent to a sump tank. The oil is separated, and the water is then either discharged overboard at the surface or shunted. The following major contaminants or chemical properties exist in operational wastes.

- high salinity
- sulfides
- low pH
- high biological and chemical oxygen demand
- various metals
- crude oil compounds
- organic acids
- radionuclides

Based on the number of OCS activities that occurred in the GOM Region (2,209 exploratory wells and 2,005 development wells) and on the average quantities of wastes generated per well from 1987 through 1991 (MMS, 1993a; EPA 1993), the following annual amounts of discharges are estimated to have occurred: 5.8 MMbbl of drilling muds, 1.8 MMbbl of drill cuttings, 0.15 MMbbl of produced sands, and 660 MMbbl of produced waters (496 MMbbl of which were disposed of offshore). Offshore discharge of these wastes must be in accordance with an NPDES permit.

The Federal Water Pollution Control Act requires EPA to establish national effluent limitation standards for wastewater discharges and to develop requirements for Federal permits (NPDES). In November 1992, the EPA Region 6 issued a new NPDES general permit for existing natural gas and oil operations in the Western GOM. This permit was modified and reissued in December 1993. Significant new requirements found in this permit include:

- monitoring for toxicity of produced water
- industry reporting of NORM levels, as well as a number of other contaminant concentrations in produced water effluents and fish tissue

In addition, EPA incorporated into this permit the newly promulgated, more restrictive, effluent limitation guidelines and new source performance standards for the offshore oil subcategory. These standards:

- decrease the allowable limits of oil and grease in produced water and well treatment and completion fluids
- permit the use of a static sheen test to determine free oil rather than visual observation in most cases
- restrict the levels of mercury and cadmium in the barite used in drilling fluids
- prohibit the discharge of produced sands

In October 1993, EPA Region 6 published a proposed general permit for new sources for the Western Gulf of Mexico OCS. The permit provides the same requirements as the general permit for existing sources.

Neither of these permits cover the OCS areas east of the Mississippi River. This area is under the authority of EPA Region 4—which plans to issue a general permit for both new and existing sources for this area.

The fate and effects of OCS discharges around production platforms in open waters have been investigated extensively (USDOI, MMS, 1990d). These studies included the following:

- Offshore Ecology Investigation in Louisiana Waters, conducted by Gulf Universities Research Consortium (Ward et al., 1979)
- Central Gulf Platform Study of the Continental Shelf off Louisiana, conducted by Southwest Research Institute (Bedinger, 1981)
- Buccaneer Field Study, conducted off Galveston, Texas, by the NMFS (Middleditch, 1981a)
- Produced Water Study, conducted by Battelle for the American Petroleum Institute (Neff, Sauer et al., 1989)
- Fate and Effects of Nearshore Discharges of OCS Produced Waters, conducted by the Louisiana Universities Marine Consortium (Rabalais et al., 1991)
- Bioaccumulation of Trace Metals From Drilling Mud Barite by Benthic Marine Animals (Neff, Hillman et al., 1989)
- Input of Low-Molecular Weight Hydrocarbons From Petroleum Operations in the Gulf of Mexico (Brooks et al., 1977)
- Source and Distribution of Petroleum Hydrocarbons in the Gulf of Mexico: Summary of Existing Knowledge, conducted by Texas A&M University (Brooks, 1979)

Although the studies' conditions did not perfectly match OCS conditions (water depths in the studies are less than the average depth of OCS platforms in the GOM), they still provided insight into the fate and effects of OCS offshore operational discharges.

Conclusions of the research are summarized below:

- Areas around many of the production platforms studied showed elevated concentrations of components that could have come from the platform operations. None of the studies found detectable trace metal or petroleum hydrocarbon contamination of waters and sediments beyond 200 m from the platform.

- Decreases in faunal diversity or in the number of benthic infauna were documented around some platforms out to 300 m but, for most of the studies, not beyond small areas near the platforms.

- Some regional contamination of the GOM waters and sediments could be attributed to OCS discharges. The broad areas that were studied in the Central GOM were often characterized as contaminated with pollutants from man's activities. Some implicated the Mississippi River as the probable source (Bedinger, 1981); others attributed the contamination to the natural gas and oil industry. Neff, Hillman et al. (1989) found barium present in sediments in the study area at concentrations substantially higher than expected of clean sediments. Neff projected that the excess barium may have been from areawide platform discharges of barium-laden drilling muds and produced waters. In addition, two reports (Brooks, 1977; Brooks et al., 1979) concluded that produced waters are a source of light petroleum hydrocarbon contamination in the Texas-Louisiana shelf waters, including particularly large amounts of low-boiling aromatics such as benzene and toluene.

In addition, the MMS initiated the Gulf of Mexico Offshore Operations Monitoring Experiment - Phase I: Sublethal Responses to Contaminant Exposure in late 1992. This phase is a 3-year effort designed to assess the site-specific effects of offshore natural gas and oil drilling in areas of the GOM with long histories of energy production. This study analyzes the chemical contamination and biochemical responses immediately beneath and adjacent to three OCS platforms that have been in production from 10 to 15 years. Study results will help the MMS minimize or prevent any long-term, environmental damage from OCS activities.

Conclusion: Moderate petroleum contamination of superficial sediments occurred around production platforms—at least out to 20 m, and possibly as far out as 200 m, particularly in very shallow inner shelf sites. There was also some cumulative, regional contamination of waters and sediments in the Central GOM shelf, primarily from barium and low-boiling aromatic hydrocarbons.

Effects of Nearshore Disposal of Routine OCS Operational Wastes: A portion of the wastes generated from offshore natural gas and oil exploration and production activities are brought ashore for nearshore disposal. During 1987 through 1991, wastes typically taken to shore included some produced waters, liquid wastes (fracturing fluids, emulsifiers, workover fluids, biocides, mud additives, etc.), produced sands, and all oil-based drilling muds and cuttings. Some of these wastes can be contaminated with NORM, toxic or hazardous compounds, heavy metals, and oil and grease.

The MMS funded two studies examining the fate and effects of OCS-generated coastal discharges (Rabalais et al., 1991; Boesch and Rabalais, 1989a). In general, the studies found "that sediment contamination and associated effects on the benthos extended beyond the region in which acutely lethal concentrations of contaminants would be expected to be found in waters receiving the dispersing plume" (Rabalais et al., 1991). Locations of OCS-produced-water discharges in coastal Louisiana varied from shallow, nearshore continental shelf areas to brackish and saline coastal environments with moderately to poorly flushed waters. Other researchers examining coastal produced-water discharges documented similar impacts. These researchers included Boesch and Rabalais (1989b), Armstrong et al. (1979), Harper (1986), Kraemer and Reid (1984), Mendelssohn and McKee (1987), Middleditch (1981a and b), Neff, Sauer et al. (1989), and St. Pé (1990).

Conclusion: Significant localized impacts, especially around produced water outfalls, occurred and contributed, to a minor extent, to the regional degradation of Louisiana coastal waters. Primarily because of the results of studies, these discharges are no longer legal and are being phased out.

Effects of Onshore Disposal of Routine OCS Operational Wastes: A portion of the wastes generated from offshore natural gas and oil exploration and production activities are brought ashore for disposal. During 1987 through 1991, wastes typically taken to shore included some produced waters, liquid wastes (fracturing fluids, emulsifiers, workover fluids, biocides, mud additives, etc.), produced sands, and all oil-based drilling muds and cuttings. Some of these wastes can be contaminated with NORM, toxic or hazardous compounds, heavy metals, and oil and grease.

About 25 percent (estimated at 165 MMbbl/yr) of the produced waters generated on the OCS were piped onshore to Louisiana shoreline facilities for treatment rather than discharged in surface coastal waters (Rabalais et al., 1991). No produced waters were allowed to be transported to other States. The onshore storage and disposal of solid wastes in nearshore areas caused impacts during 1987 through 1991. Those OCS waste types brought onshore for disposal and not discharged into surface waters were disposed of at waste treatment facilities or pits. These wastes were transported from the platform by supply boats/barges to industry shore bases or commercial oil-field waste transfer stations. Once ashore, many of these wastes were transported via barge or truck to sites farther inland for storage and disposal. Disposal practices included commercial landfarming and landfilling, burial, or transfer to onshore pits. There were no regulations requiring documentation of OCS-generated waste disposal until to 1990, when the State of Louisiana enacted an oil-field waste manifest system.

A comprehensive study completed by the EPA found that improper storage of drums and incorrect disposal of oil-field wastes adversely affected surrounding surface waters and wetland areas in Louisiana (EPA, 1988). Furthermore, discarded oil-field equipment and cleaning of the equipment affected human health and contaminated surrounding storage sites, cleaning sites, scrap yards, and metal reclamation yards. Production tubing, holding tanks, separators, heater treaters, and other like equipment often are contaminated with scale material containing NORM. In 1990, the State of Louisiana passed comprehensive oil-field waste management regulations that required the cleanup of many oil-field wastes sites and imposed strict future disposal practices (LAC Title 43: Part XIX, Amendment to Statewide Order No. 29-B). Louisiana's oil-field storage and disposal sites received oil-field wastes from a number of sources, including OCS-generated wastes.

Conclusion: The storage and disposal of non-OCS and OCS oil-field wastes and contaminated oil-field equipment adversely affected surface and ground waters in proximity to storage and disposal sites, cleaning sites, and scrap yards. However, the State of Louisiana passed comprehensive oil-field waste management regulations in 1990 that will affect future cleanup procedures.

Effects of OCS Platform/Structure/Pipeline Emplacement: In the GOM from 1987 through 1991, 802 platforms were installed and 448 platforms were removed. During this time, approximately 3,665 miles of pipeline also were constructed.

Sediment disturbance and suspension result from pile driving and anchoring during the installation of offshore platforms and pipelines. Disturbance also results from dredging during preparation of foundations for production platforms. For those pipelines laid in water depths shallower than 61 m, MMS requires burial below the seafloor. About 5,000 m^3 of sediment is assumed to be displaced for each kilometer of pipeline buried. These activities produce a local and temporary impact on water quality.

Conclusion: Construction and burial of pipelines and emplacement of platforms/ structures caused temporary and localized increases in turbidity and displacement of sediment in the GOM Region from 1987 through 1991. However, no significant cumulative impacts to water quality were identified.

Effects of OCS Oil Spills: From 1987 through 1991, three large pipeline spills ($\geq$1,000 bbl) occurred in the GOM (see table 3.4-2). These spills originated 30-70 miles offshore. There were also 163 smaller (>1-999 bbl) OCS spills totaling 1,987 bbl.

The severity of an oil-spill effect on water quality depends on a number of factors:

- type of oil
- location
- season
- weather and sea conditions

In the open ocean and in moderate to high seas, spills are dispersed and weathered by physical and biological processes such as evaporation, oxidation, emulsification, and uptake and metabolism by marine organisms. In areas contacted directly by a spill, before weathering has ceased, parameters such as oil and grease, trace metals, dissolved oxygen, hydrocarbons, biological oxygen demand (BOD), and turbidity change by several orders of magnitude. Hydrocarbon levels within affected areas may be elevated up to 100+ μg/l (Fiest and Boehm, 1980). Much of the oil is dispersed throughout the water column over several days to weeks.

Greater effects can occur if a spill contacts a sensitive nearshore area, where oil may become entrained in suspended particles and bottom sediments. Compared to offshore areas, the water quality in enclosed embayments and estuaries would be more highly affected because the weathering processes and the wind and sea state are generally much less severe. In addition, the BOD would be proportionally higher, as would toxic compound levels, while light transmittance levels would be decreased.

Conclusion: Despite possible impacts, no cumulative effects on water quality from OCS-related spills in the GOM Region from 1987 through 1991 were recorded.

4.1A2 Air Quality

Air quality is affected by emissions from all direct and support activities for OCS natural gas and oil operations such as exploratory drilling, construction, development/ production operations, and support aircraft and vessel traffic. Other emission sources are accidental events such as oil spills and blowouts.

The largest sources of pollution are power generation equipment on OCS platforms, such as gas turbines and diesel engines used to run drilling rigs, and pumps. Most of the emissions are NO_x. Crew and supply boats are also major sources of NO_x. The exact amount of NO_x emitted from these sources depends upon the operating characteristics of the engines, such as the size, type and period of use, as well as the type of fuel burned.

VOC emissions come from the transfer and transport of the oil to shore and from fugitive sources. The majority of these compounds can be emitted during the loading of barges carrying crude oil from the producing platforms to shore. Unless vapor balance lines are used, hydrocarbon vapors from previous shipments remain in the ship's hold until they are pushed out into the air when a new shipment of oil is loaded.

Fugitive sources include valves, flanges, and pumping equipment through which oil and gas are transported.

The sulfur dioxide (SO_2) emissions depend largely on the sulfur content of fuels used (diesel or natural gas) and on the hydrogen sulfide (H_2S) content of the gas that is often produced with the crude oil and gas. Large amounts of SO_2 can be emitted from facilities producing sour natural gas, which contains a relatively high concentration of H_2S.

The TSP and CO are emitted from diesel engines in such small quantities that they are not pollutants of concern with regard to the national ambient air quality standard (NAAQS). Similarly, lead is not considered relevant to NAAQS because the amount emitted from the burning of fuels in so small.

Table 4.1-3 summarizes the average annual emissions from all direct and support activities for OCS natural gas and oil operations in the GOM for the period 1987 through 1991. These emissions are calculated using procedures and emission factors presented in EPA AP-42 (EPA, 1985). According to calculations of the total annual average emissions, table 4.1-3, NO_x was emitted in the highest amounts, followed by total hydrocarbons (THC) and CO.

In some areas of coastal Texas and Louisiana, ozone concentrations do not meet the Federal standards (i.e., nonattainment areas). The EPA designated the following Louisiana coastal parishes as nonattainment areas for ozone: St. Bernard, Orleans, Jefferson, Lafourche, St. Charles, St. Mary, Lafayette, Calcasieu, Iberville, Ascension, and St. James. Also, the EPA designated the following Texas counties as nonattainment areas for ozone: Jefferson, Orange, Nueces, Victoria, Brazoria, Galveston, Harris, and Chambers. Concentrations of pollutants other than ozone for which health standards are set by EPA—nitrogen dioxide (NO_2), SO_2, CO, and TSP—are within the NAAQS for all areas of the GOM.

Table 4.1-3. OCS Average Annual Air Quality Emissions in the Gulf of Mexico, 1987 through 1991					
	Pollutant Emissions (tons)				
Activity	NO_x	CO	SO_x	THC	TSP
Service Vessels	16,252	4,247	1,088	577	1,625
LTO Helicopters	3,597	11,882	317	3,760	396
Cruise Helicopters	350	1,000	75	82	100
Spills	0	0	0	510	0
Barge Loading	0	0	0	178	0
Barge Transit Loss	0	0	0	340	0
Barge/Tugboat Exhaust	651	32	8	29	39
Exploration Wells	6,142	902	522	203	389
Development Wells	4,130	606	349	137	261
Platforms	94,669	12,354	168	35,945	232
Pipeline Construction	4,442	1,451	750	481	447
Total	130,233	32,474	3,277	42,242	3,489

LTO = landing/takeoff

The MMS performed several modeling analyses, using the Offshore and Coastal Dispersion model, to examine cumulative effects of OCS activities on concentrations of NO_2, SO_2, CO, and TSP.

- One modeling analysis (USDOI, MMS, 1986) examined the area offshore Grand Isle, Louisiana, which contained 85 production complexes located from 5.6 to 45.0 km (3.5-28.0 mi) offshore. The study showed that the OCS activities were responsible for 1.8 $\mu g/m^{-3}$ of the average annual NO_2 concentration in onshore ambient air—this increase did not exceed the NAAQS.

- Another modeling analysis (USDOI, MMS, 1989), covering the areas off Galveston, Brazos, and High Island, Texas, examined 250 offshore sources. This study showed that OCS sources increased the average annual NO_2 concentration of onshore ambient air by less than 1.0 $\mu g/m^{-3}$—this increase did not exceed the NAAQS.

- Finally, a modeling analysis (USDOI, MMS, 1991a), covering the area offshore Texas, contained 47 OCS sources (31 existing platforms and 16 proposed platforms). The highest annual increment of NO_2 concentration of onshore ambient air was 0.08 $\mu g/m^{-3}$—this did not exceed the NAAQS.

- Recently, the MMS, in cooperation with EPA, conducted a cumulative analysis of ozone using the Regional Oxidant Model. The analysis included onshore emissions in Texas and Louisiana, and offshore emissions from State and OCS oil operations. Two ozone exceedance episodes were selected for the years 1988 and 1990. The results indicated that the ozone concentrations over water ranged from 11 to 29 parts per billion, while over land contributions ranged from 5-8 parts per billion. However, the model did not have sufficient resolution to allow a quantitative evaluation of effects for specific areas onshore.

- Currently, the MMS is conducting a study of the effects of OCS emissions on ozone levels in coastal areas of Texas and Louisiana. This study was mandated by the 1990 Clean Air Act Amendments and examines the effect of emissions from OCS oil and gas development activities on air quality in the following ozone nonattainment areas: Houston-Beaumont and Galveston-Port Arthur in Texas and Baton Rouge and Lake Charles in Louisiana.

  The study consists of three phases: a comprehensive GOM emissions inventory; a field program to collect meteorological and air quality data at offshore, onshore, and aerial sites; and an evaluation of the contribution of OCS emissions to ozone levels using the variable grid Urban Airshed Model.

  This study, to be completed in 1995, will establish whether present OCS activity significantly contributes to violations of the federal ozone standard in the nonattainment areas. The study results will allow MMS to determine the effect of changes in OCS emission levels on onshore air quality. Following completion of the study, MMS will consult with the EPA to determine whether changes are needed in the air quality regulations for the Central/Western GOM Planning Areas.

Effects of OCS Drilling: From 1987 through 1991, approximately 2,209 exploration wells and 2,005 development wells were drilled in the GOM Region. The average annual emissions of regulated pollutants during the drilling activities are given in table 4.1-3.

Conclusion: Drilling emissions are temporary, and concentrations are diluted as they travel the distance from the offshore source to shore. Air quality modeling analyses indicated that these OCS drilling activities did not contribute significantly to ambient air pollutant concentrations onshore.

Effects of OCS Platform Operations and Associated Emissions: In the GOM, there are approximately 3,800 OCS production platforms, 1,106 of which contain sources that emit air pollutants (1,039 in Louisiana and 67 in Texas). These platforms are distributed over an area of 30,000 mi^2 off the Texas and Louisiana coasts. From 1987 through 1991, 802 platforms were installed, while 448 platforms were removed—a net increase of 354 platforms. However, as natural gas and oil are depleted over time, production decreases; this decrease results in a downward trend in emissions. The average annual regulated pollutants emissions from platforms in the GOM Region for 1987 through 1991 are presented in table 4.1-3.

Conclusion: Air quality modeling performed for the areas with high concentrations of NO_x emission sources, showed that estimated NO_2 impacts at the shoreline were not significant and did not cause the onshore NO_2 concentrations to exceed the NAAQS. There are no nonattainment areas for NO_2 in the GOM coastal areas.

Effects of OCS Support Vessel Traffic: For the period 1987 through 1991, approximately 1 million OCS-related helicopter trips (a trip being 1 takeoff and 1 landing), 440 barge trips, and 52,000 service vessel trips occurred annually in the GOM Region. Emissions from these activities are presented in table 4.1-3. Their combined NO_x emissions represent about 16 percent of the total NO_x emissions from OCS activities in the GOM during this time.

Conclusion: Because of the small amount of emissions from OCS support vessel traffic spread over the entire GOM Region, no significant effects to air quality from this source occurred during this period.

Effects of OCS Hydrocarbon Venting and Offloading: In the GOM, the emission of hydrocarbons (THC) occurs during the loading and transit of barges since no tankering of OCS oil occurs in the GOM. The amount of material emitted (table 4.1-3) during these activities is 1.2 percent of the total THC emissions from OCS activities in the GOM from 1987 through 1991.

Conclusion: Due to their relatively small quantity of emissions, these activities had no significant effects on GOM air quality during 1987 through 1991.

Effects of OCS Pipeline Construction: For the period 1987 through 1991, 3,655 miles of pipeline were laid in the GOM Region using lay barges, tugs, and supply boats (table 4.1-3). The THC emissions from this activity were 14 percent of the total THC emissions from OCS activities in the GOM Region during this time.

Conclusion: Due to its relatively small quantity of emissions, this activity had no significant effect on GOM air quality during 1987 through 1991.

Effects of OCS Oil Spills: During the period 1987 through 1991, three large OCS-related pipeline spills ($\geq$1,000 bbl) occurred in the GOM (see table 3.4-2). These spills originated 30-70 miles offshore. There were also 163 smaller (>1-999 bbl) OCS spills that averaged 12 bbl.

The 510 tons of THC emissions from the two largest OCS crude oil spills (table 4.1-3) represented about 1.2 percent of the total THC emissions from OCS activities in the GOM during this time.

Conclusion: Because of the transient and localized nature of these emissions (main effects in proximity to the spill) and the relatively small amount of material released, effects from OCS oil spills on the air quality levels of GOM onshore areas were minor from 1987 through 1991.

4.1B Biological Environment

4.1B1 Lower Trophic Organisms

Effects of Offshore Discharge of Routine OCS Operational Wastes: From 1987 through 1991, approximately 5.8 MMbbl of drilling muds and 1.8 MMbbl of drill cuttings were produced annually by OCS-related activities in the GOM.

In the GOM, about 90 percent of these OCS discharges settle and dilute rapidly, usually within 1,000-2,000 m of the discharge points. Most water-based fluids are nontoxic, with their effects limited to the immediate vicinity of the discharge (NRC, 1983). In addition to toxic effects, the discharges, particularly the cuttings, form a low mound on the bottom. Nonmotile benthic organisms covered by cuttings can be smothered. To the extent that this mound exhibits sediment characteristics (such as grain size, organic content, etc.) different from the original bottom, the organisms colonizing the mound will be different. These cuttings mounds are colonized and reworked, and eventually become indistinguishable from the surrounding bottom (Zingula, 1975). Menzie (1983) points out that it is the physical change of the substrate rather than any toxic effects that causes a change in benthic fauna around OCS platforms and structures.

In addition, approximately 660 MMbbl/yr of produced water were generated by OCS activities in the GOM from 1987 through 1991. Of this volume, an estimated 496 MMbbl were disposed of offshore, and 165 MMbbl were brought onshore (in Louisiana) for disposal. Produced waters can be high in total dissolved solids, total organic carbon, petroleum hydrocarbons, some trace metals, and elemental sulfur and sulfide, and they may be low in dissolved oxygen. Therefore, produced waters can affect lower trophic organisms if in high enough concentrations. Attempts to delineate the actual contribution of OCS-produced waters to increased hydrocarbons measured in the vicinity of OCS activities have been confounded by the widespread occurrence of hydrocarbons across the OCS from natural seepage and the river transport of terrigenous hydrocarbons (as documented by Gallaway, 1988). Neff, Hillman et al. (1989) found higher levels of barium in areas where platform discharges had occurred, and attributed these increased levels to the discharge of drilling muds and produced waters.

In general, decreases in faunal diversity or in the number of benthic infauna due to OCS discharges (which included produced waters as well as drilling muds and cuttings) were documented around some platforms out to a distance of 300 m.

Conclusion: For the period 1987 through 1991, the discharge of OCS-related drilling muds and cuttings caused negligible impacts to the GOM's lower trophic organisms in the water column and to benthic fauna in close proximity to the discharge points (300 m for benthic fauna). Although water column and benthic organisms in the areas surrounding GOM production platforms were negatively affected by OCS-related produced water discharges, the areal extent of these effects was minimized by the rapid dilution and mixing in the offshore environment.

Effects of OCS Pipeline Emplacement: Approximately 3,665 miles of pipeline were constructed in the GOM from 1987 through 1991. The MMS estimates that 391 ha of bottom habitat were disturbed each year by the installation of these pipelines. In addition, in water depths less than 61 m, OCS operators are required to bury the pipelines. This burial resulted in an estimated 5,000 m^3 of sediments being resuspended for each kilometer of pipeline installed.

In the immediate vicinity of pipeline construction, lower trophic organisms are disturbed or killed by mechanical damage of the pipeline or by associated dredging and anchoring activities. In addition, displacement or resuspension of sediments smothers nonmotile benthic organisms, and increased turbidity clogs respiratory and filter-feeding mechanisms of lower trophic organisms. Although no specific studies were conducted to quantify these occurrences, studies have suggested that the effects are highly localized, and recovery from pipeline construction would occur rapidly (Wicker, 1989). Because disturbed areas did not experience a change in substrate, recovery proceeded even sooner than was observed in the studies monitoring the recolonization of benthic organisms following the discharge of muds and cuttings. Benthic organisms, as a whole, are well adapted to bottom disturbance and turbidity caused by storms and other natural events.

Conclusion: Although OCS-related pipeline construction activities negatively affected the water column and benthic organisms in the GOM, increased turbidities resulting from these activities were short term and quickly dissipated. Rapid recolonization of benthic organisms occurred in the disturbed areas.

Effects of OCS Oil Spills: From 1987 through 1991, three large OCS-related pipeline spills ($\geq$than 1,000 bbl) occurred in the GOM (see table 3.4-2). These spills originated 30-70 miles offshore. There were also 163 smaller OCS spills ($>$1-999 bbl), which spilled a total 1,987 bbl. No followup investigations of the effects of these three spills were undertaken.

Oil spills can cause death or disruption if sufficient concentrations of hydrocarbons contact lower trophic organisms. Small surface spills, however, would cause only very limited impacts to lower trophic organisms. Rapid dispersion and weathering of the oil quickly reduces the concentrations of hydrocarbons. Oil from a surface slick can be driven into the water, with measurable amounts documented at depths of about 20 m. At this depth, however, the oil is found only at concentrations several orders of magnitude lower than the amount shown to have an effect on marine organisms.

Larger subsurface spills from pipeline ruptures would have a greater potential to bring high concentrations of oil in contact with lower trophic organisms. Information about the fate of oil from subsurface spills is mainly based on the results of research teams studying the non-OCS IXTOC I exploratory well blowout in Campeche Bay, Mexico. Although most of the oil from subsurface spills surfaces quickly, approximately 3 percent of the IXTOC I oil was found to form a subsurface plume of oil droplets suspended in a mixed layer at depths of 5-20 m (Fiest and Boehm, 1980; Walter and Pronti, 1980). This subsurface petroleum plume was transported by ocean currents (Boehm and Fiest, 1982). The hydrocarbon components of the subsurface plume usually are slower to weather than surface slicks, thus causing higher concentrations of the more toxic components in the water column. The concentrations of individual hydrocarbons in the dissolved fraction measured at the IXTOC I spill appeared to lie below the toxic range even in the "acute impact zone" (Boehm and Fiest, 1980). However, the ranges for both low-molecular-weight hydrocarbons (the more toxic fractions of the oil) and total waterborne oil were well within the range causing observable effects to marine organisms.

Conclusion: It is probable that the three large OCS-related pipeline spills caused disruption to lower trophic organisms in the upper water column (especially the top 6 m of the water column, based on information from Fiest and Boehm, 1980). However, lower trophic organisms of the benthos were probably unaffected since the concentrations of oil reaching them were greatly diminished (except in the immediate area of the pipeline ruptures).

4.1B2 Special Benthic Communities

(a) Live Bottoms (Pinnacle Trend)

Seventy lease blocks containing live bottoms are located in the northeastern portion of the Central GOM and adjacent areas of the Eastern GOM. These blocks are associated with the pinnacle trend located between 73- and 101-m water depths in the Main Pass and Viosca Knoll lease areas (see fig. 4.1-5 for location of these lease areas). The pinnacles include recently documented live-bottom areas that may be sensitive to natural gas and oil activities. Since 1980, the OCS lease sales contain a Live Bottom Stipulation—a regulation that prohibits lessees from siting platforms directly on pinnacles.

Prior to any OCS activities on the 70 lease blocks containing live bottoms, the lessee must submit to the MMS a live bottom survey report containing a bathymetry map. The map will verify the presence or absence of live bottoms that could be affected by the proposed OCS activity. If live bottoms might be adversely affected by the proposed OCS activity, the MMS will require the lessee to undertake any measure deemed economically, environmentally, and technically feasible to protect the pinnacle area. This stipulation is designed to protect the pinnacles from damage resulting from drilling activities and anchor emplacement, the major OCS activities affecting these live bottoms.

Effects of OCS Platform/Structure Emplacement and/or Removal: For the period 1987 through 1991, 802 OCS platforms were installed. Four of these structures were installed on leases associated with the pinnacle trend. The MMS, through the Live Bottom Stipulation, prohibits lessees from siting platforms directly on pinnacles. In addition, 448 OCS platforms were removed; none of the removals were associated with the pinnacle trend.

The placement of drilling rigs and platforms on the seafloor crushes the organisms directly beneath the legs or the mat used to support the structure. The areas affected by the placement of the platforms and rigs are soft-bottom regions where infaunal and epifaunal communities are common. Routine natural gas and oil operations can damage small portions of the benthic community. Damage from rig and platform emplacement can devastate the usefulness of the pinnacles as habitat or shelter for commercial and recreational fishes. However, OCS operators must comply with the Live-Bottom Stipulation that protects the pinnacles from damage resulting from OCS-related activities. Because of this stipulation, as well as the unevenness of the seafloor, a rig or platform cannot be sited directly on the pinnacles.

Explosive and nonexplosive structure-removal operations also disturb the seafloor and can affect nearby pinnacle communities. Structure removal using explosives (the most common removal method) suspends sediments throughout the water column to the surface and can substantially affect nearby habitats. Deposition of these sediments occurs in the same manner as that for the discharge of drilling muds and cuttings.

Effects on the pinnacle area from OCS structure removal are minimal because of the restricted regions affected by the shock from explosives, the limited duration and area of impact associated with sediment resuspensions (about 1,000 m), and the low number of structures near such regions. Localized damage can occur, but recovery to preinterference conditions would be accomplished over a short time.

Conclusion: Because of the limitations and requirements of the Live Bottom Stipulation, impacts to the pinnacle area from OCS structure emplacement and removal in the GOM from 1987 through 1991 were minimal.

Effects of Offshore Discharge of Routine OCS Operational Wastes: In the GOM from 1987 through 1991, it is estimated that approximately 5.8 MMbbl of drilling muds, 1.8 MMbbl of drill cuttings, 0.15 MMbbl of produced sands, and 660 MMbbl of produced waters (496 MMbbl of which were discharged offshore) were generated annually as a result of OCS activities.

Drilling discharges affect biological communities and organisms via turbidity and smothering of the benthos near the drill site. In the GOM Region, about 90 percent of the discharge settles rapidly, usually within 1,000-2,000 m of the discharge point. Most water-based fluids are nontoxic, and associated effects are limited to the immediate vicinity of the discharge (NRC, 1983).

Deposition of drilling muds and cuttings on the pinnacle trend area did not significantly impact the biota of the pinnacles or the habitat itself because the biota of the seafloor surrounding the pinnacles are adapted to life in turbid conditions and to high sedimentation rates. Also, existing currents in these regions prevent the accumulation of muds and cuttings. Deep water dilutes the effluent to a significant degree, and the pinnacles themselves are coated with a veneer of sediment. Additional deposition and turbidity caused by a nearby well do not adversely affect the pinnacle environment because such fluids are discharged into very large volumes of water (the open GOM) and rapidly disperse. These fluids can be measured above background levels only within 1,000-2,000 m of the discharge point, and they have few biological effects except very close to the discharge point.

Conclusion: Due to their depth, the prevailing currents, and their distance from OCS activities, live-bottom (pinnacle) communities were not affected by routine OCS operational discharges in the GOM from 1987 through 1991.

Effects of OCS Pipeline Emplacement: Pipeline emplacement affects the benthic communities by burying and disrupting the benthos and by resuspending sediments, which clog filter-feeding mechanisms and gills of fishes and sedentary invertebrates. During the report period, the MMS required OCS operators to comply with the Live Bottom Stipulation and other protective measures that severely limit OCS natural gas and oil activities in the immediate vicinity of the pinnacle communities.

Data gathered for the Mississippi-Alabama Marine Ecosystem Study (Brooks and Giamonna, 1990) have shown that dense biological communities (i.e., live-bottom communities) are concentrated on the pinnacle features themselves. Because the extent of dense biological communities is sparse in the bottom sediments surrounding the pinnacles, the effect of pipelaying activities on these communities is restricted to the resuspension of sediments. At the community level, the severity of effects from pipeline emplacement in the GOM was slight, with no measurable interference to the general ecosystem.

Conclusion: Because OCS activities in the immediate vicinity of the pinnacle communities were restricted by the Live Bottom Stipulation, and the effect of pipelaying activities was limited to the resuspension of sediments, no measurable interference to the general ecosystem of these areas occurred as a result of these activities in the GOM from 1987 through 1991.

Effects of OCS Anchoring Activities: Anchor placement is the most serious threat to live-bottom areas and can damage lush biological communities or the structure of the pinnacles themselves. The size of the affected area depends on the depth of water, length of chain, size of anchor and chain, method of placement, wind, and current. Anchor damage includes crushing and breaking pinnacles and associated communities. Anchoring often destroys a wide swath of habitat when the anchor is dragged or when the vessel swings at anchor, causing the anchor chain to drag on the seafloor.

Conclusion: Because the MMS required OCS operators to comply with the Live Bottom Stipulation (which prohibited lessees from siting platforms on pinnacles), anchoring events did not affect live bottoms in the GOM from 1987 through 1991.

Effects of OCS Oil Spills: During 1987 through 1991, three large OCS-related pipeline spills ($\geq$than 1,000 bbl) and 163 smaller (>1-999 bbl) OCS oil spills occurred in the GOM. The large pipeline spills originated 30-70 miles offshore.

Conclusion: None of the large OCS-related pipeline oil spills originated near the pinnacle trend, and no adverse effects to the pinnacle trend from OCS spills were reported.

(b) Deep-Water Benthic (Chemosynthetic) Communities

The deep-water benthic communities, found in waters deeper than 400 m, derive their energy from chemosynthetic processes rather than the photosynthetic processes of shallow-water communities. The primary chemosynthetic organisms are bacteria, both free-living (as "bacterial mats") and symbiotic in the tissues of other organisms, especially in the gills. The predominant large benthic organisms are tube worms, clams, and mussels. These deep-water benthic chemosynthetic communities are of low density and are widespread throughout the deep-water areas of the GOM. These chemosynthetic communities (living among natural gas and oil bubbles) use petroleum hydrocarbons as a food source.

High-density, Bush Hill-type communities are areas of high biomass associated with hydrocarbon seeps and natural gas- and/or oil-charged sediments. These chemosynthetic areas are considered most at risk from OCS natural gas and oil operations. Because of the recent discovery of this type of community, its vulnerability, recoverability, and general extent are unknown. To determine the geological, geochemical, physiological, and ecological factors that control the formation and continued existence of these communities, the MMS initiated the Gulf of

Mexico Chemosynthetic Ecosystems Study in 1991 (in progress). The MMS undertook this study as an initial step to protect the chemosynthetic communities from harmful OCS-related impacts. Remote sensing instruments, bottom samplers, and manned submersibles are being used to collect site-specific samples and data to determine the biological composition of these communities and the physical-chemical factors which influence or limit their distribution, abundance, and growth.

The MMS NTL 88-11 (effective February 1, 1989) requires the mandatory identification and avoidance of "plush" chemosynthetic communities (such as Bush Hill-type) or areas supporting these communities. Under the provisions of this NTL, the MMS requires lessees operating in water depths greater than 400 m to examine the geophysical records for conditions that might support chemosynthetic communities. If such conditions exist, the lessee must either move the operation or provide photodocumentation of the presence/absence of the Bush Hill-type of chemosynthetic communities. When such communities are present, no drilling operations are permitted in the area. Although the NTL requirements are effective, a small percentage (estimated 10-15%) of chemosynthetic community areas may not be properly identified. As new information becomes available, the MMS will modify the NTL requirements as necessary.

The OCS-related activities affecting deep-water benthic communities are those that disturb the bottom: anchoring, drilling, pipeline installation, and seafloor blowout accidents. Routine OCS natural gas and oil effluent discharges such as muds, cuttings, and sanitary wastes do not affect chemosynthetic communities because of the rapid dilution and dispersion of effluent components in deep water. In addition, MMS NTL 88-11 prevents OCS-related activities from adversely affecting these communities.

Effects of OCS Platform/Structure/Pipeline Emplacement and Anchoring Activities: In the GOM for the period 1987 through 1991, 802 OCS platforms were installed, and 3,665 miles of OCS pipeline were laid.

The presence of a conventional structure scours the surficial sediments (Caillouet et al., 1981), and routine drilling disturbs the sea bottom. Pipelaying activities in the OCS can destroy chemosynthetic organisms. In deep-water areas far from an existing pipeline network, shuttle tankering transports the product, thus eliminating effects of pipeline construction to these deep-water communities. Anchors or buoys from OCS support vessels, floating drilling units, and pipelaying vessels disturb small areas of the seafloor. The area affected depends on the water depth, length of the chain, size of the anchor, and water current. Anchoring destroys those sessile organisms hit by the anchor or anchor chain during anchoring or anchor weighing.

Conclusion: Because the MMS requires lessees to identify and avoid lush chemo-synthetic communities (Bush-Hill type) when siting and anchoring OCS-associated structures and vessels (NTL 88-11), and absent the 10-15% misidentification rate, no known effects occurred to these communities from these OCS-related activities in the GOM during 1987 through 1991.

Effects of Reservoir Depletion: Little is known about how OCS-associated hydrocarbon withdrawal affects chemosynthetic organisms, which use petroleum hydrocarbons as a food source. The seeps and vents around which these organisms live are pressurized from the deep reservoirs that force the gas or oil to the seafloor. When all of the recoverable hydrocarbons from these reservoirs are withdrawn, the natural gas and oil venting/seepage could slow or stop.

Current information is inconclusive as to whether decreasing the pressure driving the seeps would be reduced quickly or whether there may be enough oil already in the "conduit" to the surface to continue the seepage. Although this effect is not clearly understood, the level of OCS development in deep-water areas is too low to deplete the hydrocarbon energy source significantly. Ongoing and planned studies of these communities by the MMS may provide additional information on the effects of reservoir depletion.

Conclusion: No effects of reservoir depletion from OCS development were known to occur in the GOM Region from 1987 through 1991.

(c) Topographic Features

The sensitive biological habitats of the topographic features are rare occurrences of hard-bottom communities in an otherwise soft-bottom environment. The organisms of these habitats include typical reef occupants such as corals, coralline algae, sponges, and reef fish. The areas of hard-bottom are quite small and are scattered generally along the shelf break off Louisiana and Texas (USDOI, MMS, 1992c).

Topographic features inhabited by benthic hard-bottom communities characterize the shelf edge of the Central and Western GOM. These habitats are important in several respects:

- They support hard-bottom communities of high biomass and high diversity, as well as a large number of plant and animal species.

- They support, either as shelter or food or both, large numbers of commercially and recreationally important fishes.

- They are unique to the extent that such habitats are small isolated areas of communities in the vast, relatively monotonous GOM regions of much lower biomass and diversity.

- They (especially the East and West Flower Garden Banks) provide a relatively pristine area suitable for scientific research.

- They have an aesthetical intrinsic value.

The benthic organisms associated with topographic features are limited by temperature and light (Rezak et al., 1983). Elevated temperatures result in thermal stress by causing the corals' zooxanthellae to be expelled; where light is limited, coral growth is inhibited. Therefore, coral growth is limited by water depth and by distance from the surrounding substrate and the nepheloid (turbid) layer.

The Topographic Features Stipulation (part of appropriate leases in the GOM since 1973) establishes a "no activity zone" where no bottom-disturbing activities are permitted. The stipulation also establishes other areas around the no activity zones in which shunting of all drill effluents towards the sea bottom is required. The effectiveness of this stipulation is well documented (Rezak et al., 1983; 1985).

To evaluate the adequacy of current MMS stipulations that are designed to protect the important biological resources of the Flower Garden Banks, the MMS began the Flower Garden Banks Monitoring Study in 1994 (currently in progress). This study is a cooperative effort with the National Oceanic and Atmospheric Administration's (NOAA's) National Marine Sanctuary Program to monitor the environmental conditions at the East and West Flower Garden submarine banks. The biological health of the reef crest, especially coral reefs and coralline algae, will be monitored over a long period of time to detect any subtle chronic effects from natural and man-induced activities that potentially could endanger community integrity. Observations will be used to evaluate coral reef diversity, growth rates, long-term changes in individual coral colonies, accretionary growth, and general community health.

Effects of Offshore Discharge of Routine OCS Operational Wastes: Discharges of OCS drilling muds and cuttings cause localized water turbidity, deposition on the surrounding seafloor, and potential effects of low concentrations of toxic constituents. Most water-based fluids are relatively nontoxic, and their effects are limited to the immediate vicinity of the discharge (NRC, 1983); discharge of the more toxic oil-based muds is prohibited by the EPA. The water depths from which the topographic features rise range from 50 to 175 m, depths that dramatically increase the dilution of drilling effluents. In the GOM, about 90 percent of the discharge settles rapidly, usually within 1,000-2,000 m of the discharge site (NRC, 1983).

Choi (1982) found that drilling discharges (muds and/or cuttings with iron flakes) were trapped in coral and coral rubble only up to a distance of 100 m from the wellhead. Coelobite communities therein were largely disturbed only up to 40 m from the drill site, with minor changes evident out to 100 m. Effluents discharged at the water's surface within 1,000 m of a bank affected the biota of the bank, although the currents tended to keep the bank swept clean of fine sediments and would prevent the accumulation of drilling muds.

Produced water, along with injection water and other additives, can be a hazard to the biota of topographic features. This water contains high concentrations of inorganic salts ranging from 3 to 300 parts per thousand. Conversely, hydrocarbons, other organic compounds, and trace metals may be present at parts per million levels in the produced water discharges (U.S. Department of Commerce [USDOC], NOAA, National Marine Fisheries Service [NMFS], 1977; EPA, 1991). The Topographic Features Stipulation requires that discharges in zones around the high relief banks be shunted to prevent adverse effects to the biota of the banks.

Conclusion: Because the MMS required OCS operators to adhere to the Topographic Features Stipulation, operational discharges (drilling muds, drill cuttings, and produced waters) had little effect on the biota of the banks.

Effects of OCS Platform/Structure/Pipeline Emplacement and Anchoring Activities: Structure emplacement (pipeline, drilling rig, or platform) and anchoring of OCS pipeline, lay barges, drilling rigs, or service vessels disturb the benthic environment. Topographic features could be disturbed or devastated by mechanical damage from pipeline construction or associated dredging and anchoring activities. Anchor damage is the most serious threat to the biota of the offshore banks (Bright and Rezak, 1978; Rezak et al., 1985).

Conclusion: Because the Topographic Features Stipulation precluded these activities in the "no activity zone," adverse effects to topographic features from these factors, as well as factors associated with OCS structure removal, were prevented in the GOM from 1987 through 1991.

Effect of OCS Oil Spills: From 1987 through 1991, three large OCS-related pipeline spills ($\geq$1,000 bbl) occurred in the GOM (see table 3.4-2), as did 163 smaller (>1-999 bbl) OCS spills. The large pipeline spills originated 30-70 miles offshore.

Conclusion: None of the large OCS-related pipeline spills originated on or proximate to any lease block associated with topographic features during the report period, and no adverse effects to these features from OCS oil spills were recorded.

4.1B3 Fish Resources

Effects of OCS Seismic Surveying: Seismic surveys are systematically executed, and any effects on fish resources constitute, at most, short-term avoidance behavior and do not adversely affect harvestable fish populations in the GOM. The sources of acoustical pulse used in seismic surveys are generated by air guns or water guns, which have little effect on even the most sensitive fish eggs at distances of 5 m from the discharge (Chamberlain, 1991; Falk and Lawrence, 1973). In general, the acoustical pulse from air guns or water guns has relatively little effect on marine invertebrates, presumably due to the invertebrates' lack of a swim bladder. Available scientific information concerning the effects of acoustic pulses from air guns and water guns on fish eggs and larvae indicates that commercial fishery resources are little disturbed by seismic surveying (Wingert, 1988).

Conclusion: Commercial fisheries were not affected by OCS-related seismic surveying conducted in the GOM from 1987 through 1991.

Effects of Offshore Discharge of Routine OCS Operational Wastes: From 1987 through 1991 in the GOM, approximately 5.8 MMbbl of drilling muds, 1.8 MMbbl of drill cuttings, 0.15 MMbbl of produced sands, and 660 MMbbl of produced waters were generated annually as a result of OCS activities. Approximately 165 MMbbl of these produced waters were annually disposed of at Louisiana onshore facilities.

Discharged drilling muds at the drill site contain materials toxic to fish resources, but only at concentrations four or five orders of magnitude higher than those found more than a few meters from the discharge point (NRC, 1983; Parrish and Duke, 1990). Further, dilution is extremely rapid in offshore waters to such an extent that every substance measured in the water column is at background levels found at a distance of 1,000 m from the discharge point (ECOMAR, Inc., 1980; Proni, 1984). Drill cuttings, rock particles, or fragments displaced as the drill moves through various geological formations are separated and washed free of any oil-based drilling muds and are not toxic to marine fishes (NRC, 1983). Cuttings do not smother fish resources because of the way cuttings settle to the bottom (Abernathy, 1989). In quiescent situations, a cutting mound may develop and may be used by a number of benthic organisms. In turn, these organisms may act as food for fish resources in the vicinity (Gallaway, 1981).

In addition to toxic trace elements and hydrocarbons in formation waters, there are additional components and properties (such as hypersalinity and organic acids) that affect fish resources. However, formation waters discharged offshore are diluted, are dispersed rapidly, and are undetectable at a distance of 1,000 m from the discharge point—detectable effects are limited to within 300 m of the source (Harper, 1986; Rabalais et al., 1991).

The effects of formation waters discharged into inshore and protected waters are considerable on highly localized populations of fish resources (Boesch and Rabalais, 1989a and b). Formation waters discharged into fish nursery areas can decrease or eliminate food sources for juveniles of finfish. Direct ingestion of, or long-term exposure to, contaminated sediments can have a lethal/sublethal effect on shellfish. Oysters located near and inshore of discharge sites bioaccumulate hydrocarbons from formation waters (Boesch and Rabalais, 1989a and b). This accumulation can render oysters unmarketable in the short term and can cause sublethal effects in the long term to all life stages of oysters. The areal extent of sediment contamination and potential adverse effects from formation waters discharged within inshore protected waters may extend 50-1000 m from the discharge point (Boesch and Rabalais, 1989a and b). Sixteen GOM coastal facilities separate formation waters from product streams originating in the OCS and discharge the formation waters at 11 sites, which are located exclusively in Louisiana (Boesch and Rabalais, 1989a and b).

Some formation waters contain NORM because oil is extracted from reservoir rock where NORM is formed by the radioactive decay of naturally occurring uranium and thorium. Data collected from offshore platforms discharging NORM in formation waters show that epifaunal and associated organisms within 3 m of the discharge do not accumulate radium at high levels (Mulino and Rayle, 1992). The levels of radioactivity measured in soft tissue and hard parts of all biota tested (barnacles, mollusks, fish, blue crabs) were near the lower limit of detection. Any radium concentrations above this lower limit were in inedible hard parts (shell or bone).

Conclusion: During the period 1987 through 1991, drilling muds and cuttings did not adversely impact fish resources because of the processes of dilution and settling. In fact, cutting mounds may attract benthic organisms that are a source of nourishment to many fish resources. Also, NORM discharged into offshore formation waters did not affect fish resources.

Effects of OCS Platform/Structure Emplacement and/or Removal: During 1987 through 1991, 802 OCS platforms were installed, and 448 were removed.

The presence of offshore structures can benefit fish resources. During the period 1987 through 1991, an average of 3,800 platforms operated throughout the GOM, extending from offshore Alabama to the southern reaches of Texas. The areas occupied by platforms constitute over 28 percent of the hard substrate found in this otherwise soft-bottom environment (Gallaway, 1984; Stanley et al., 1991). Due to the limited amount of hard-bottom substrate in the offshore waters from Mississippi to Texas, the expansion of the natural gas and oil industry provided a significant proportion of the habitat for organisms dependent on hard substrate and those that are structure-related, such as snapper and grouper (Gallaway and Lewbel, 1982). Natural gas and oil platforms in the GOM are popular fishing destinations for both sport and commercial fishermen, thus providing evidence of their effectiveness as artificial reefs (Stanley and Wilson, 1989).

Platform removal, however, can adversely affect fish. The MMS requires lessees to remove all structures and underwater obstructions from their leases in the Federal OCS within 1 year of the lease's relinquishment or termination of production. Lessees removed 448 of these structures from the GOM during 1987 through 1991. Eighty percent of multi-leg platforms in water depths less than 156 m are removed by severing their pilings with explosives placed 5 m below the seafloor. The resulting concussive force is lethal to fish that have internal air chambers (swim bladders), are demersal, or are in close association with the platform being removed (Scarborough-Bull and Kendall, 1992; Young, 1991). Within the past decade, stocks of reef fish have declined in the GOM. There is concern over a possible connection between this decline and the explosive removal of platforms. To examine this issue, the MMS entered into a formal Interagency Agreement with the NOAA to investigate fish mortality associated with structure removal. This investigation will attempt to relate the role of fish mortality from platform removals to the status of reef fish stocks in the GOM (USDOI, MMS, 1990c).

The realization of the value of active platforms, while in place, to commercial and recreational fishing has prompted Federal, State, and private interests to consider expanded use of these structures as artificial reefs. Most obsolete platforms are removed from the seabed and hauled ashore for salvage as scrap. In recent years, however, the value of these structures as artificial habitat for marine life has been widely recognized. Each of the coastal States in the GOM is active in developing local plans and in permitting and siting artificial reefs. In fact, many of these plans involve the siting of oil and gas structures (Gould et al., 1991).

The 1986 Louisiana Fishing and Enhancement Act established an artificial reef program and required the development of a plan covering both State and Federal waters off the Louisiana coast. Through 1991, 13 obsolete platforms were sited in Louisiana artificial reef planning areas on the OCS. In 1989, Texas enacted a law calling for an artificial reef plan advisory council and trust fund to facilitate the development of a rigs-to-reef program offshore Texas. Through 1991, six platform jackets were sited at Texas artificial reef sites (D. Cranswick, MMS GOM Region, oral. comm., June 1994).

Conclusion: Platform emplacement provided additional habitat (hard substrate) not usually found in the soft-bottom environment of the Gulf of Mexico. However, limited local adverse effects from platform removals occurred (e.g., fish kills associated with platform removal).

Effects of OCS Oil Spills: During the period 1987 through 1991, three OCS-related pipeline spills ($\geq$1,000 bbl) occurred in the GOM. These spills originated 30-70 miles offshore. Also, 163 smaller (>1-999 bbl) OCS spills (totaling 1,987 bbl) occurred in the GOM during this time.

When an oil spill occurs, many factors limit the severity of effects and the extent of damage to fish populations. The direct effects on fish result from the ingestion of oil or oiled prey, the uptake of dissolved petroleum products through the gills and epithelium by adults and juveniles, and the mortality of eggs and decreased survival rate of larvae (NRC, 1985). Upon exposure to spilled oil, liver enzymes of fish oxidize soluble hydrocarbons into compounds that are easily excreted in the urine (Spies et al., 1982). When contacted by spilled oil, floating eggs and larvae, with their limited mobility and physiology, and most juvenile fish are killed (Linden et al., 1979; Longwell, 1977). Ordinary environmental stresses also can increase the sensitivity of fish to oil toxicity. These stresses include changes in salinity, temperature, and food abundance (Evans and Rice, 1974; NRC, 1985).

Observations of non-OCS oil spills, including the *Exxon Valdez* spill in Prince William Sound, Alaska, consistently indicate that free-swimming fish are rarely at risk from oil spills (Oil Spill Intelligence Report, 1991; NRC, 1985). Fish usually swim away from spilled oil, and this behavior explains why there has never been a commercially important fish-kill on record following an oil spill. The only recorded adult fish-kill of this type was on the French coast when several tons of small rock-clinging fish (not commercially harvested) were killed at the site of the *Amoco Cadiz* wreck.

Conclusion: Despite possible impacts from OCS-related oil spills, no cumulative oil-spill effects on fish resources were recorded in the GOM from 1987 through 1990.

4.1B4 Endangered or Threatened Species

The only endangered or threatened species found in the GOM Region from 1987 through 1991 were marine turtles and Alabama, Choctawhatchee, and Perdido Key beach mice.

(a) Marine Turtles

There are several types of GOM marine turtles: the loggerhead, Kemp's ridley, hawksbill, green, and leatherback. Major factors affecting marine turtles are reviewed in detail in *Decline of the Sea Turtles; Causes and Prevention* (NRC, 1990).

Effects of OCS Platform/Structure/Pipeline Emplacement: During 1987 through 1991, 802 OCS platforms and 3,665 miles of OCS pipeline were installed. Structure installation and pipeline placement affect marine turtle habitat by destroying the seagrass beds and live-bottom communities used by these turtles. The physical integrity, species diversity, and biological productivity of topographic features and live bottoms where marine turtles occur may undergo temporary damage or disturbance from these activities.

The MMS implemented biological stipulations for live-bottom areas to protect these communities from OCS-related physical disturbance.

Conclusion: Any disturbances to marine turtle habitat, feeding behavior of marine turtles, and prey availability during the report period were minor and temporary.

Effects of OCS Support Vessel Traffic: From 1987 through 1991, approximately 440 OCS-related barge trips and 52,000 OCS-related service vessel trips occurred annually in the GOM. Noise from and contact with support vessels can affect marine turtles.

Noise from OCS support vessel traffic can elicit a startle reaction from marine turtles and can produce temporary sublethal stress (NRC, 1990). Vessel collision with marine turtles is rare because turtles spend less than 4 percent of their total time at the sea's surface (Byles, 1989; Lohoefener et al., 1990). Although vessel traffic (OCS and non-OCS) is responsible for approximately 9 percent of all marine turtle deaths in the southeastern United States (Teas and Martinez, 1992), the OCS support vessel contribution of this percentage is unknown.

Conclusion: Besides the temporary effects from noise, OCS support vessels accounted for a minor percentage of vessel traffic-related marine turtle deaths in the GOM from 1987 through 1991.

Effects of Offshore Discharge of Routine OCS Operational Wastes: During 1987 through 1991, approximately 5.8 MMbbl of drilling muds, 1.8 MMbbl of drill cuttings, 0.15 MMbbl of produced sands, and 660 MMbbl of produced waters (496 MMbbl of which are discharged offshore) were generated annually as a result of OCS activities. Offshore operational discharges are not lethal; they dilute and disperse rapidly within 1 km of the discharge point. Most water-based fluids are nontoxic, and associated effects are limited to the immediate vicinity of the discharge (NRC, 1983).

Suspended particulate matter in offshore operational discharges reduces visibility and displaces prey items in the vicinity. Marine turtles within 1 km of discharge points might be less successful in locating prey during the short time they traverse any discharge plumes. However, unfavorable effects on marine turtle food sources by OCS-related water quality degradation were not demonstrated during 1987-1991 (American Petroleum Institute, 1989; NRC, 1983).

Conclusion: The link between OCS-associated water quality degradation from the discharge of routine operational wastes and health effects on migratory marine vertebrates, such as marine turtles, is inconclusive—no OCS-related mortality estimates are available (NRC, 1990).

Effects of OCS Platform/Structure Removal: Most OCS platforms and other structures (well jackets and caissons) are efficiently and economically removed using explosive charges. From 1987 through 1991, explosives were used to remove 448 OCS platforms in the GOM. However, aerial surveys in the Central GOM showed that the only statistical correlation between marine turtles and OCS structures is near the Chandeleur Islands, Louisiana (Lohoefener et al., 1990).

Explosive platform removals can cause capillary damage, disorientation, and loss of motor control in marine turtles (Duronslet et al., 1986). Although marine turtles far from the site may suffer only disorientation, those near detonation sites can sustain fatal injuries. To prevent marine turtles injuries, the MMS issued the following guidelines (NTL 88-11) for explosive platform removal to offshore operators:

- daylight-limited detonation
- staggered charges
- placement of charges 5 m below the seafloor
- pre- and post-detonation surveys of surrounding waters

In addition to the above mitigation, the MMS and NMFS are investigating procedures to determine the risk to sea turtles from OCS structure removals and to minimize potential effects further.

Conclusion: Because of MMS mitigation, no mortalities to marine turtles due to OCS-related platform/structure removals in the GOM were documented during 1987 through 1991.

Effects of OCS-Related Plastic Debris: Marine debris is a source of mortality and debilitation for marine turtles (Plotkin and Amos, 1988; NRC, 1990). During the period 1987 through 1991, the volunteer beach cleanup programs in Texas and Louisiana picked up, on average, more than a ton of refuse and debris for every mile of beach cleaned in those States. The predominant sources of this debris were merchant shipping, the oil and gas industry (State and OCS being indistinguishable), and fishing operations. In addition to the incremental amount of trash and debris generated by the OCS program and other U.S. entities, marine debris is carried into the GOM from South and Central America, Europe, and North Africa (Plotkin and Amos, 1988; Hutchinson and Simmonds, 1992). The volume of nonbiodegradable materials contributed by these sources is unknown.

Turtles that consume or become entangled in debris may die or become debilitated (O'Hara, 1989; USDOC, NOAA, NMFS, 1989; Heneman and the Center for Environmental Education, 1988). Ingestion of plastic and styrofoam materials could result in drowning, lacerations, and reduced mobility followed by starvation (Carr, 1987; USDOC, NOAA, 1988; Heneman and the Center for Environmental Education, 1988; NRC, 1990).

The MMS prohibits the disposal of OCS equipment, containers, and other materials into offshore waters by lessees (30 CFR 250.40). In addition, MARPOL Annex V, Public Law 100-220 (101 Statute 1458), prohibits the disposal of any plastics at sea or in coastal waters. The MMS-funded "Project MMS-Beach" (Amos, 1993 draft report) will ascertain the effectiveness of MARPOL Annex V in reducing the manmade debris littering barrier island beaches in Texas. Litter data were collected in 1987 and 1988 (before MARPOL Annex V was enacted) and again in 1991 and 1992. Preliminary findings show that items associated with the offshore oil industry (State and OCS) have decreased—however, a relationship with MARPOL Annex V cannot be statistically determined.

Conclusion: Despite various safeguards, marine turtles can become entangled in or ingest offshore natural gas- and oil-associated debris. Distinguishing between State and OCS programs is infeasible. However, there were no documented marine turtle deaths due to OCS-associated plastic debris in the GOM from 1987 through 1991.

Effects of OCS Oil Spills: During the period 1987 through 1991, three OCS-related pipeline spills ($\geq$1,000 bbl) occurred in the GOM (see table 3.4-2). These spills originated 30-70 miles offshore. There were also 163 smaller (>1-999 bbl) OCS spills.

Contact with oil might not cause direct or immediate mortality, but cumulative sublethal effects could impair the marine turtle's ability to function effectively in the marine environment (Lutz and Lutcavage, 1989). When an oil spill occurs, the severity of effects and the extent of damage to marine turtles depend on geographic location, oil type and dosage, impact area, and oceanographic and meteorological conditions (NRC, 1985). Spilled oil affects marine turtles by toxic external contact, toxic ingestion or blockage of the digestive tract, disruption of salt gland functions, asphyxiation, and displacement from preferred habitats (Witham, 1978; Vargo et al., 1986; Lutz and Lutcavage, 1989). Marine turtles also become entrapped by tar and oil slicks and are rendered immobile (Witham, 1978; Plotkin and Amos, 1988)—in the past, tanker washings have been the main source of this oil (van Vleet and Pauly, 1987). Hatchling and small juvenile turtles are vulnerable to contacting or ingesting oil because the currents that concentrate oil spills also form the debris mats in which these turtles are sometimes found (Carr, 1980; Collard and Ogren, 1990). Fritts and McGehee (1982) noted that contact with weathered oil released from the IXTOC I spill off Mexico in 1979 damaged sea turtle eggs. During nesting season, the Kemp's ridley turtle is vulnerable to harm from a large oil spill occurring in the immediate vicinity of Tamaulipas, Mexico—the only known nesting beach for these turtles (Lutz and Lutcavage, 1989).

In addition, oil-spill response activities, such as vehicular and vessel traffic, in shallow areas of seagrass beds and live-bottom communities can affect sea turtle habitat and can result in displacement. As mandated by the Oil Pollution Act of 1990, these areas will receive individual consideration during oil-spill cleanup. Required oil-spill contingency plans include special notices to minimize adverse effects from vehicular traffic during cleanup activities and to maximize protection efforts to prevent contact of these areas by spilled oil.

Conclusion: Despite possible effects, no adverse effects to marine turtles from OCS-related oil spills were reported in the GOM from 1987 through 1991.

(b) Alabama, Choctawhatchee, and Perdido Key Beach Mice

Alabama, Choctawhatchee, and Perdido Key beach mice—designated protected species under the Endangered Species Act—occupy restricted habitat behind coastal foredunes in Florida and Alabama (Ehrhart, 1978; USDOI, FWS, 1987). Their range is in the Perdido Key State Preserve (Florida), Grayton Beach State Recreational Area (Florida), St. Andrews State Recreational Area (Florida), Gulf Islands National Seashore (Alabama), and Gulf State Park (Alabama). Portions of these areas are designated as critical habitat. Natural catastrophes, including storms, floods, droughts, and hurricanes, have substantially reduced or eliminated these beach mice. In fact, strong storms in the last decade caused local extinctions (Humphrey and Frank, 1992).

Effects of OCS Oil Spills: During the period 1987 through 1991, three OCS-related pipeline spills ($\geq$1,000 bbl) and 163 smaller (>1-999 bbl) OCS spills occurred in the GOM. These spills originated 30-70 miles offshore.

Beach mice habitat is located behind barrier dunes (Ehrhart, 1978), so an OCS oil spill must breach the dunes to reach the mice. This contact could only occur if the OCS oil spill coincided with a storm surge. Direct contact with spilled oil causes skin and eye irritation, asphyxiation from inhalation of toxic fumes, food reduction, food contamination, oil ingestion, increased predation, and displacement from preferred habitat.

Vehicular traffic associated with OCS oil-spill activities can degrade the mice's preferred habitat and can cause displacement. Protection efforts to prevent spilled oil contact with mice habitats are mandated by the Oil Pollution Act of 1990. Because of the critical designation and general status of protected species habitats, oil-spill contingency plans include requirements to minimize adverse effects from vehicular traffic during oil-spill cleanup activities and to maximize efforts for protection from oil-spill contact.

Conclusion: Because OCS-associated oil spills did not reach the coastline near beach mice habitats from 1987 through 1991 in the GOM Region, no OCS-related effects occurred in these areas.

4.1B5 Marine Mammals

With the exception of the bottlenose dolphin and the Atlantic spotted dolphin, the majority of marine mammals inhabiting the GOM belong to the Order Cetacea (whales, dolphins, and porpoises) and typically are found in the deep waters of the continental shelf edge and beyond. Dolphins also inhabit nearshore and shelf waters (Mullin et al., 1991).

Effects of OCS Seismic Surveying: Seismic surveying uses an acoustic pulse generated by compressed air. Sound pulses exceeding ambient noise levels affect cetacean communication and behavior. Although ambient noise levels in the marine environment are highly variable, the effects of noise generated from seismic surveys are limited because the noise dissipates to less than 200 dB at distances beyond 30 m from the acoustic source (Gales, 1982). Seismic surveys are systematically executed, and cetaceans could easily avoid the presence or approach of the acoustic source within the open waters of the GOM. The effects of seismic surveys on cetaceans constitute, at most, short-term avoidance behavior and do not adversely affect populations within the GOM.

Conclusion: No effects of seismic surveying on marine mammals were noted in the GOM during the period 1987 through 1991.

Effects of Offshore Discharge of Routine OCS Operational Wastes: From 1987 through 1991, approximately 5.8 MMbbl of drilling muds, 1.8 MMbbl of drill cuttings, 0.15 MMbbl of produced sands, and 660 MMbbl of produced waters were generated annually from OCS activities.

Routine OCS operational discharges affect cetaceans by displacing or removing food sources or degrading water quality. When released in offshore areas, these discharges rapidly dilute and disperse and are not lethal or detrimental to cetaceans (American Petroleum Institute, 1989; NRC, 1983). Onshore discharges, however, can enter coastal waters and degrade the water quality. Coastal populations of bottlenose dolphins are susceptible to the effects from pollutants within these areas. Recent studies (USDOC, NOAA, NMFS, 1990c) focusing on the cause of death and stranding of several bottlenose dolphins within the southern United States found elevated levels of contaminants within surrounding coastal waters subsequent to the "die offs." Results from these studies, however, do not reveal any relationship between OCS operational discharges and recent dolphin die-offs.

Conclusion: There was no documented evidence showing that routine OCS operational wastes discharged in the GOM from 1987 through 1991 detrimentally affected marine mammals living offshore or in coastal waters.

Effects of OCS Support Vessel Traffic: For the period 1987 through 1991, approximately 1 million helicopter trips (a trip being 1 takeoff and 1 landing), 440 barge trips, and 52,000 service vessel trips occurred annually in the GOM Region from OCS-related activities.

Helicopters and support vessels traveling near cetaceans can elicit a startle response and avoidance or evasive behavior. Although these effects are sublethal, they can disrupt temporarily any ongoing feeding, mating, resting, or migratory behavior, or can cause the dispersion of a social group.

Cavitation and irregularities of the propeller are the sources for underwater noise from OCS support vessels. Other noises are emitted from the main engine(s) and auxiliary machinery. The response of cetaceans to noise is species specific and depends on several factors: function of sound intensity, distance that the noise source is in motion (compared to a static and nonchanging source), season (primarily mating season), and individual variability in cetacean behavior. Certain whales reduced their use of areas heavily traveled by ships, though the continued presence of other whale species in the same area indicates a considerable degree of tolerance to ship noise and disturbance (Richardson et al., 1991). Groups of dolphins and porpoises are often attracted to vessels to bowride or, in the case of fishing vessels, to take advantage of discarded bycatch.

Any OCS support vessel surveying, servicing, or shuttling can collide with cetaceans, especially larger species and those remaining at the surface for extended periods of time (United Press International, 1986). Many of the larger species of nonendangered cetaceans are deep-diving odontocetes (toothed) which commonly spend extended periods of time at the surface to restore oxygen levels within their tissues. The normal distribution of these mammals is beyond the continental shelf edge, well into the bounds of the continental slope, and beyond most locations of OCS activities. Cetaceans inhabiting the continental shelf and nearshore waters, such as bottlenose and spotted dolphins, are agile swimmers. They often approach and are able to avoid vessels even when in narrow navigational passes and waterways.

Conclusion: Noise from OCS helicopter and service vessel traffic periodically disturbed marine mammals in the GOM during 1987 through 1991. No collisions between marine mammals and OCS support vessels were reported during this time.

Effects of OCS-Related Operational Noise: From 1987 through 1991, 2,209 OCS exploration wells and 2,005 OCS development wells were drilled. During this timeframe, an average of 3,800 OCS platforms operated throughout the GOM, extending from offshore Alabama to the southern reaches of Texas.

The OCS exploration, delineation, and production structures and drillships produce an acoustically wide range of sounds at various frequencies and intensities, many of which are detectable by cetaceans. Odontocete cetaceans use sounds for acoustic echolocation and communication at frequencies higher than the those generated by OCS drilling and production activities. Baleen whales utter sounds at frequencies below 1 kilohertz, which overlap broadly with the dominant frequencies in many industrial sounds (Malme et al., 1989; Richardson et al., 1991). The drilling noises from conventional OCS metal-legged structures and semi-submersibles are not intense and are strongest at low frequencies, averaging 5 hertz and 10-500 hertz, respectively. The OCS drillships produce higher levels of underwater noise than other types of platforms (Richardson et al., 1991).

Conclusion: There was no evidence to show that the relatively continuous, static noises produced by OCS drilling and production operations permanently displaced marine mammals or caused observable disruption of their behavior in the open waters of the GOM during 1987 through 1991.

Effects of OCS Platform/Structure Removal: For the period 1987 through 1991, 448 OCS platforms were removed. Removal of offshore platforms using explosive charges (the most common method) can affect cetaceans.

The effects on marine mammals of underwater detonation of explosive charges depend on several factors: the amount of explosive used, distance from the charge, and the mammal's body mass. Hemorrhaging in and around the lungs is the primary source of injury to submerged marine mammals, as well as injuries from the effects of explosive impact upon gas bubbles within the intestines (Goertner, 1982). Explosions can damage the ears of submerged cetaceans, thus affecting communication, feeding, and navigation. Although OCS-related mortalities and permanent injuries to marine mammals could occur, none were documented from 1987 through 1991 in the GOM. The preventive measures issued by the MMS (e.g., NTL 88-11, discussed under endangered or threatened marine turtles) ensure that explosive platform removals do not affect marine mammals within the GOM.

Conclusion: During the period 1987 through 1991, no marine mammal injuries or mortalities were observed in conjunction with explosive platform removals in the GOM.

Effects of OCS-Related Plastic Debris: From 1987 through 1991, the volunteer beach cleanup programs in Texas and Louisiana picked up, on average, more than a ton of refuse and debris for every mile of beach cleaned in those States. The predominant sources of this debris were merchant shipping, the oil and gas industry (State and OCS being indistinguishable), and fishing operations. In addition to the incremental amount of trash and debris generated by the OCS program and other U.S. entities, marine debris is carried into the GOM from South and Central America, Europe, and North Africa (Plotkin and Amos, 1988; Hutchinson and Simmonds, 1992). The volume of nonbiodegradable materials contributed by these sources is unknown.

Pollution of the marine environment with nonbiodegradable plastic debris discarded from offshore sources (OCS structures and OCS-related and non-OCS vessels) and coastal sources (litter and solid waste disposal) is an issue of increasing concern, especially with regard to entanglement of and ingestion by marine mammals. Typically, marine mammals become entangled in various types of debris and inactive or active fishing gear (mostly fishing lines of various types). Plastic debris was found in the gut contents of several stranded marine mammals; in some cases, ingestion of such material was determined to be the cause of death (Barros and Odell, 1990; Sadove and Morreale, 1990; Tarpley, 1990). Apparently, the animals either mistook the plastic material suspended in the water column as a food item or, in the case of larger baleen whales, ingested it along with prey species (Sadove and Morreale, 1990).

Regulations prohibiting disposal of plastic debris and other materials are addressed earlier in this report in the discussion on endangered or threatened marine turtles.

Conclusion: During 1987 through 1991, there were documented marine mammal deaths attributed to plastic debris ingestion or entanglement; however, the sources of these plastic materials were difficult to ascertain. In fact, OCS lessee/operator adherence to MMS policy and MARPOL regulations reduced the disposal of OCS-related plastic debris into the waters of the GOM.

Effects of OCS Oil Spills: During the period 1987 through 1991, three large ($\geq$1,000 bbl) OCS oil spills and 163 smaller (>1-999) OCS oil spills occurred in the GOM. The three large pipeline spills originated 30-70 miles offshore. Although oil spills and oil-spill response activities can affect cetaceans, there were no documented effects on marine mammals from these occurrences in the GOM during this time.

Direct contact with oil and/or tar can result in irritation and damage to skin and soft tissues (such as mucous membranes of the eyes), fouling of baleen plates so as to hinder the flow of water and interfere with feeding, and incidental ingestion of oil and/or tar. Studies by Geraci and St. Aubin (1982, 1985a) have shown, however, that the cetacean epidermis functions as an effective barrier to noxious substances found in petroleum. Penetration of such substances into cetacean skin is impeded by tight intercellular bridges, the vitality of the superficial cells, the thickness of the epidermis, and the lack of sweat glands and hair follicles. Cetacean skin is free from hair or fur, which in other marine mammals (such as pinnipeds and otters) tends to collect oil and/or tar; this collection of oil reduces the skin's insulative properties (Geraci, 1990).

Inhalation of toxic vapors can result in irritated respiratory membranes, lung congestion, and pneumonia. Subsequent absorption of volatile hydrocarbons into the bloodstream may accumulate into organs such as the brain and liver, causing neurological disorders and damage (Geraci and St. Aubin, 1982; Hansen, 1985; Geraci, 1990). Geraci and St. Aubin (1982) determined that toxic vapor concentrations found just above the water's surface (where cetaceans draw breath) could reach critical levels for the first few hours after a spill, prior to any evaporation of volatile aromatic hydrocarbons and other light fractions. Cetaceans do not use their sense of smell to detect and avoid such slicks.

The effect on cetaceans swimming through an oiled area depends on their ability to escape from the vicinity, their health, and their immediate response to stress. Spilled oil temporarily alters migration routes and reduces or contaminates prey. Cetaceans can ingest oil-contaminated food or floating or submerged oil or tar.

Cetaceans exhibit various reactions to spilled oil, with evidence of direct avoidance or obvious indifference in even heavily oiled areas. Observations of most cetaceans confronting spilled oil show them behaving normally in the vicinity, and in some cases in the midst, of a spill. It is unknown whether these animals are unaffected by the presence of oil or if they are drawn to the area in search of prey organisms attracted to the oil's protective surface shadow (Geraci, 1990). However, controlled experiments on detection and avoidance response of bottlenose dolphin to oil films found that dolphins can see oil at the surface and that they avoid it (Geraci et al., 1983; Smith et al., 1983; St. Aubin et al., 1985).

Oil-spill response activities include applying dispersant chemicals designed to break up oil on the water's surface into minute droplets, which then break down in seawater. Nothing is known about the effects of oil dispersants on cetaceans; however, removing the oil from the water's surface reduces the risk of oil contact and the likelihood of oil adherence to skin, baleen plates, or other body surfaces (Neff, 1990). When compared with that of crude oils and refined products, the acute toxicity of most oil dispersant chemicals is low. The rate of biodegradation of dispersed oil is equal to or greater than that of undispersed oil (Wells, 1989). Biodegradation is another process for removing petroleum hydrocarbons from the marine environment, using chemical fertilizers to augment the growth of naturally occurring hydrocarbon-degrading microorganisms. The toxic effects of these fertilizers on cetaceans are currently unknown.

Conclusion: Studies indicated that responses of some marine mammal species to surface spills varied, and those animals not avoiding spills could have been exposed to lethal concentrations. However, no OCS-related marine mammal mortalities were documented in conjunction with the OCS oil spills that occurred in the GOM during the period 1987 through 1991.

4.1B6 Coastal and Marine Birds

The GOM and its contiguous waters and wetlands are populated by five main groups of resident and migratory species of coastal and marine birds: seabirds, shorebirds, wading birds, marsh birds, and waterfowl.

Effects of OCS Support Vessel Traffic: Transporting supplies, materials, and personnel between the coastal infrastructure and OCS structures is accomplished using helicopters and a variety of service vessels. For 1987 through 1991, approximately 1 million helicopter trips (a trip being 1 takeoff and 1 landing), 440 barge trips, and 52,000 service vessel trips occurred annually in the GOM Region as a result of OCS-related activities.

Mechanical noise or the physical presence (or wake) of OCS-related traffic can disturb coastal birds. The degree of disturbance exhibited by groups of coastal birds to air or vessel traffic is highly variable, depending upon the following:

- species
- type of vehicle
- altitude or distance of the vehicle
- frequency of occurrence of the disturbance
- season

Encounters with vessel traffic can cause temporary cessation of feeding, resting, breeding, and/or nesting activities of coastal and marine birds. Disturbance can also lead to a permanent desertion of active nests or of critical or preferred habitat. This desertion could contribute to the relocation of a species or group to less favorable areas or to a decline of species populations through reproductive failure.

The Federal Aviation Administration (Advisory Circular 91-36C) and corporate helicopter policy in the GOM state that helicopters must maintain a minimum altitude of 700 feet while in transit offshore, and 500 feet while working between platforms. When flying over land, helicopters must maintain a minimum altitude of 1,000 feet over unpopulated areas or across coastlines, and 2,000 feet over populated areas and biologically sensitive areas (wildlife refuges and national parks) (USDOI, MMS, 1992c).

When operational altitude is constrained by inclement weather, low-flying aircraft, especially helicopters, can startle birds, causing short-term disruptions in normal behavior. Generally, this startle response lasts for only a few minutes after which birds return to their normal behavior with no lasting effect. However, during the breeding season, low-flying helicopter traffic may cause birds to abandon their nests temporarily. This abandonment can result in reduced productivity by exposing eggs and young to extreme temperatures, predation, and injuries. This startle response is tempered, to a large degree, by the well-known ability of birds to habituate to regularly occurring, chronic noises (Krebs, 1980; Johnson et al., 1985; Stephen, 1961; Langowski, 1969; Sharp, 1987). The time required and degree of habituation vary with the species, previous experience, frequency and nature of the disturbance, and time of year.

Conclusion: Disturbance to coastal and marine birds from OCS support vessel traffic from 1987 through 1991 was from low-flying helicopters whose operational altitude was constrained by inclement weather. Traffic at standard operational altitudes, however, did not appear to disturb birds in GOM coastal areas during this time.

Effects of OCS-Related Plastic Debris: During the period 1987 through 1991, the volunteer beach cleanup programs in Texas and Louisiana picked up, on average, more than a ton of refuse and debris for every mile of beach cleaned in those States.

The predominant sources of this debris were merchant shipping, the oil and gas industry (State and OCS being indistinguishable), and fishing operations. In addition to the incremental amount of trash and debris generated by the OCS program and other U.S. entities, marine debris is carried into the GOM from South and Central America, Europe, and North Africa (Plotkin and Amos, 1988; Hutchinson and Simmonds, 1992). The volume of nonbiodegradable materials contributed by these sources is unknown. Regulations prohibiting the disposal of plastic debris and relevant MMS-funded programs were already addressed in the discussion on endangered and threatened marine turtles.

Coastal and marine birds are highly susceptible to entanglement in floating, submerged, and beached marine debris, specifically plastics discarded from both offshore sources and from land-derived litter and waste disposal (Heneman and Center for Environmental Education 1988). Studies in Florida reported that 80 percent of the brown pelicans showed signs of injury from entanglement with fishing gear (Clapp and Buckley, 1984). In addition, seabirds ingest this debris more frequently than do any other taxon (Ryan, 1990). Ingested debris has three basic effects on seabirds (Ryan, 1990; Sileo et al., 1990): irritation and blockage of the digestive tract, impairment of foraging efficiency, and release of toxic chemicals.

Long-term effects of plastic ingestion include physical deterioration from malnutrition—plastics often cause a distention of the stomach, thus preventing its contraction and simulating a sense of satiation (Ryan, 1988). Some birds also feed plastic debris to their young, which could result in reproductive failures. In addition to obstruction and impaction of the gut, some plastics can have high levels of chemical toxicity and can pose a significant hazard (Fry et al., 1987). Sileo et al. (1990) found that the prevalence of ingested plastic found within the gut of examined birds varied greatly among species. Those species that seldom regurgitate indigestible stomach contents are most prone to the aforementioned adverse effects (Ryan, 1990). Within the GOM, these species include the phalaropes, petrels, storm-petrels, and shearwaters.

Conclusion: From 1987 through 1991, there were some documented coastal and marine bird deaths and injuries attributed to plastic debris ingestion or entanglement; however, the sources of the debris are difficult to ascertain. Adherence by OCS lessees/operators to MMS policy and MARPOL regulations served to reduce disposal of OCS-related plastic debris into the waters of the GOM.

Effects of OCS Oil Spills: During the period 1987 through 1991, there were 166 OCS oil spills in the GOM: 3 large pipelines spills ($\geq$1,000 bbl—see table 3.4-2) and 163 smaller (>1-999 bbl) OCS platform and pipelines spills averaging 12 bbl. The three large pipeline spills originated 30-70 miles offshore.

The birds most vulnerable to direct oil-spill effects include those species that spend most of their time swimming on and under the sea surface, and that often aggregate in dense flocks (Piatt et al., 1990; Vauk et al., 1989). This group includes loons, grebes, sea ducks and pochards, and cormorants. Coastal birds (including shorebirds, waders, marsh birds, and certain waterfowl) may be the hardest hit indirectly through destruction of their feeding habitat and/or food source (Hansen, 1981; Vermeer and Vermeer, 1975). Direct oil contact with birds usually has fatal effects, such as hypothermia, shock, drowning, and starvation (Knaus, 1990; Vermeer and Vermeer, 1975; Fry and Lowenstine, 1985). Oil and tar readily fouls and mats plumage, with subsequent loss of water repellency, thermal insulation, buoyancy, and the ability to fly and forage (Ambrose, 1990; Fry et al., 1985; Clark and Gregory, 1971). An oiled bird will preen its contaminated feathers and down to remove the oil and/or tar, often denuding areas of the body; this accelerates the loss of body heat. Preening also results in incidental ingestion and inhalation of oil, with accompanying secondary toxic effects (Butler et al., 1988; Levy, 1983). Oil can also be directly transferred by the adult to incubating eggs or chicks.

Consequential toxic effects of ingested oil are highly variable, depending upon the type of oil and amount ingested. Toxicity can be acute, with resultant physiological changes and damage to internal organs, or it can produce long-term effects in exposed adults, in chicks exposed to oil or fed contaminated food, and in chicks hatched from eggs of exposed birds (Fry et al., 1985).

Oil-spill cleanup methods often require heavy trafficking of beaches and wetland areas, application of oil dispersant and bioremediation chemicals, and distribution and collection of oil-containment booms and absorbent material. The presence of humans—along with boats, aircraft, and other technological creations—could result in additional disturbance of coastal birds after a spill. Investigations show that oil-dispersant mixtures pose a threat to the reduction of productivity in birds similar to the threat from oil (Albers, 1979; Albers and Gay, 1982). The external exposure of adult birds to oil-dispersant emulsions may reduce chick survival more than exposure to oil alone; however, successful dispersal of a spill will generally reduce the probability of exposure of coastal and marine birds to oil (Butler et al., 1988).

Conclusion: Despite potential effects from OCS-related oil spills, no effects to coastal and marine bird populations in the GOM Region were reported during the report period.

4.1B7 Coastal Wetlands

The MMS defines "wetlands" as those areas periodically inundated or saturated by surface or ground water and that predominantly support vegetation typically adapted for life in saturated soil conditions. Coastal wetlands are affected by canals, pipelines, navigational traffic, support facilities, and oil spills. Structures engineered to mitigate secondary adverse impacts are effective when maintained for the life of the topographic modifications they were designed to mitigate. If not properly maintained, these structures can cause the following adverse significant impacts:

- saltwater intrusion
- reduction of freshwater head
- sediment erosion and export
- expansion of tidal influence
- habitat conversion

For example, dams, weirs, or bulkheads are constructed across canals to impede the exchange of water through canals. Success of this type of mitigation depends on hydrologic patterns, soil characteristics, facility maintenance, erosion rates, and subsidence rates in the affected vicinity of the project. A poorly designed or poorly maintained mitigation structure can cause more damage to wetlands than it was designed to prevent.

Dredged material from construction and maintenance dredging should be considered for use as a sediment supplement in deteriorating wetland areas to enhance and increase wetland acreage, where appropriate. Disposal of dredged material for marsh enhancement has been done only on a limited basis in the GOM. Based on the COE mission, increased emphasis has been placed on the use of dredged material for marsh creation.

Effects of OCS-Related Vessel Traffic on Navigational Channels: All OCS-related vessel traffic in the GOM uses existing navigational channels; the OCS fraction accounts for about 12 percent of all vessel use. The 40 existing channels used by OCS-related vessels in the GOM from 1987 through 1991 are composed of canals, bayous, and rivers found in the coastal regions; these channels totalled 2,158 km and 1,023 km, respectively, in the Central and Western GOM.

Navigational channels are regularly surveyed to determine the need for maintenance dredging. The resulting spoil usually is deposited onto existing spoil banks or established spoil deposition areas. New spoil disposal areas are permitted and mitigated through the permitting process of the COE and State CZM programs. Some dredged material intended for placement on a spoil bank is inadvertently placed in adjacent wetlands or shallow water. The resulting wetland loss is offset by wetland creation, as adjacent margins of shallow water are filled. Hence, effects of spoil disposal on wetlands are minimal, with some localized, significant, hydrological problems.

In addition, the use of waterways by vessels destroys wetlands and natural levees by creating wakes and water surges which, in turn, erode channel banks and flush sediments from adjacent wetlands. Based on information from Johnson and Gosselink (1982), the MMS estimates that OCS-used navigational channels widen at a rate of 1.5 m/yr.

Conclusion: The widening of navigational channels in the GOM caused the loss of approximately 1,220 ha of wetlands during 1987 through 1991. Based on the fraction of OCS-related vessel use, 12 percent of this loss (approximately 147 ha) was attributable to OCS activities.

Effects of OCS-Related Onshore Pipeline Construction: Pipeline construction affects approximately 1.05 ha/km in the deltaic region of Louisiana and 0.68 ha/km in other areas of the Central and Western GOM. (MMS estimates are based on information from Turner and Cahoon, 1987, and Wicker et al., 1989).

Modern installation methods and planning procedures have reduced the levels of impacts from these activities on wetlands. Directional boring to emplace pipelines at barrier beach landfalls and under sensitive surface features eliminates adverse impacts to those features. After backfilling, a pipeline right-of-way revegetates or remains as a shallow-water body (Tabberer et al., 1985; Turner and Cahoon, 1987; Wicker et al., 1989). Turner and Cahoon (1987) determined that 77 percent of all existing OCS-related pipeline canals were backfilled, partially filling the canal. In areas where soils have high organic content, a canal is not usually filled completely after backfilling. In areas with soils containing low organic content, most of the canal length is usually filled and naturally revegetated after backfilling.

Structures constructed to mitigate effects associated with pipeline construction frequently fail (Johnson and Gosselink, 1982), resulting in significant effects on wetlands (Johnson and Gosselink, 1982; Tabberer et al., 1985; Turner and Cahoon, 1987). This failure can lead to the following:

- expansion of tidal influence
- flank subsidence
- hydrodynamic alterations
- sediment export
- habitat conversion
- saltwater intrusion
- impounded submergence
- accelerated erosion
- induced development

These effects are geographically variable, primarily in relation to the distribution of OCS activities, maintenance of mitigation structures, and organic content of surface sediments. The effects are more severe in wetland habitats of Louisiana's Deltaic Plain where soils have the highest organic content and where OCS production occurs nearby. The effects are progressively lower in regions where soils are lower in organic content and where OCS production and supply centers are not proximate—such as in the Louisiana Chenier Plain region, and in the States of Mississippi, Alabama, and Texas.

Conclusion: Many OCS-related inland pipelines and mitigative efforts contributed to locally significant cumulative effects on the coastal wetlands of the GOM during 1987 through 1991.

Effects of OCS Oil Spills: During 1987 through 1991, three OCS-related pipeline spills ($\geq$1,000 bbl) occurred in the GOM (see table 3.4-2). These spills originated 30-70 miles offshore. There were also 163 small (>1-999 bbl) OCS spills, totaling 1,987 bbl.

Offshore oil spills can come from platform accidents, pipeline breaks, or navigational accidents. When these spills contact wetlands, the oil can affect wetland vegetation for long periods of time.

Onshore OCS-related oil spills can come from pipeline accidents and barge or shuttle tanker accidents during transit or offloading operations. These oil spills are usually either confined within facility containment levees and do not contact wetlands, or they are contained and managed as a result of spill prevention and central countermeasure plans required for such facilities, thereby having little effect on wetlands.

Numerous investigators studied the immediate effects of oil spills on wetland habitats in the GOM area. Often, diverse conclusions were generated by these studies because of different oil concentrations contacting vegetation, the kinds of oil spilled (heavy or light crude, diesel, fuel oil, etc.), the types of vegetation affected, the season of year, the pre-existing stress level of the vegetation, and numerous other factors.
In overview, the data suggest that light oiling effects include plant die-back, with recovery within two growing seasons or less without artificial replanting; this effect is considered short term and reversible. In stressed environments such as those found in coastal Louisiana, wetlands are more sensitive to oil contact than elsewhere in the GOM (Webb et al., 1985; Alexander and Webb, 1987; Lytle, 1975; Delaune et al., 1979; Fischel et al., 1989).

The only effective mitigation for oil spills is rapid and timely deployment of oil-spill containment and cleanup personnel and equipment to avoid oil contact with wetlands and to reduce the duration and oil-concentration of contact where it does occur.

Shoreline erosion is accelerated at those sites where oil spills damage the vegetation fringing and protecting canal banks and other shorelines, shoreline erosion is accelerated at those sites (Alexander and Webb, 1987). Although significant and long-term damage to marsh vegetation may not occur, important components of marsh productivity (infauna, epifauna, and epiflora) can be destroyed. The extent of this loss depends upon the nature of the oil spill, the extent of vegetation killed, the water levels while oil is present, and the time of year.

Conclusion: For the period of 1987 through 1991, significant impacts to wetlands from OCS oil spills were not reported.

4.1C Socioeconomic Environment

4.1C1 Employment and Demographic Conditions

The social and economic well-being of 75 coastal and inland counties/parishes in the five States bordering the GOM coastal zone are directly or indirectly affected by the OCS natural gas and oil industry. The counties/parishes include areas where offshore natural gas and oil support activities are known to exist. Also included are entire Metropolitan Statistical Areas in cases where at least one county/parish of the area contains known offshore natural gas- and oil-related activities.

The OCS-related socioeconomic factors are direct, secondary, and tertiary in nature. Direct employment associated with the OCS natural gas and oil industry consists of those workers involved in the following activities (covered under the Standard Industrial Classification Code 13—Oil and Gas Extraction):

- natural gas and oil exploration, development, and production operations
- geophysical and seismographic surveys
- exploratory drilling
- well operations
- maintenance
- other contract support services

Secondary activities from the primary natural gas and oil extraction industry include the following:

- natural gas and crude oil processing in refineries, natural gas plants, and petrochemical plants
- oil and natural gas transportation
- related machinery manufacturing

Finally, induced activities in numerous tertiary industries (e.g., service and trade establishments) are attributable to direct and secondary offshore activities. Induced employment in tertiary industries is generated from both direct and indirect employment and consists of jobs that are created or supported by the expenditures of employees in primary and secondary industries. Induced employment results from the demand for consumer goods and services such as food, clothing, housing, and entertainment. It includes, but is not limited to, employment associated with the following activities:

- construction
- manufacturing
- transportation and public utilities
- wholesale and retail trade
- services

The MMS completed three contracted studies in the GOM Region which analyzed and documented the relationship of OCS natural gas and oil activity to onshore employment effects. The first study (Resource Economics & Management Analysis, Inc., 1987) discussed in-house preparation of a regionalized input/output model to estimate indirect employment and population effects. The second study (Centaur Associates, Inc., 1986) examined the locational distribution of direct OCS employment by place of work versus place of residence. The third investigation (McKenzie et al., 1993) addressed the direct employment and population effects of the downturn in OCS activity since 1986.

To determine what effects OCS-related activities had on employment and demographic conditions, conversions of actual OCS activities to direct, secondary, and tertiary employment and population effects are done. The following direct effects are assumed:

- One exploratory rig can drill an average of nine wells per year with approximately 133 workers.
- One platform rig can drill an average of six wells per year with a crew of approximately 155 workers.
- One offshore platform can operate with an average crew of 28 workers.

The following secondary and tertiary effects are made:

- The ratio of secondary employment to direct employment is 0.67.
- The ratio of tertiary employment to the sum of direct and secondary employment is 0.33.
- The ratio of population to total employment effect is approximately 2.0.

These conversions allow estimates of total direct, secondary, and tertiary employment and population effects for any year based on actual OCS activity. These OCS-related estimates are then compared to total (i.e., OCS and non-OCS related) population and employment levels in the coastal region, as provided by the USDOC to determine the level of OCS-related impact.

Conclusion: As a percentage of total employment and population, the OCS-related impact varies with the coastal subarea. Outside coastal Louisiana, OCS-related activity accounted for less than 1 percent of total employment and population—this amount is negligible. Within coastal Louisiana (particularly in the southwest portion), OCS-related activity accounted for as much as 10 percent of the total employment and population.

Estimates of OCS-related direct employment and total employment in the GOM Region for the calendar years 1987 through 1991 are listed in table 4.1-4.

Table 4.1-4. Estimated Direct OCS-Related Employment and Population in the Gulf of Mexico Region, 1987-1991

Date of Estimate	Direct OCS-Related Employment	Total OCS-Related Employment
October 1987	49,600	104,800
September 1988	39,500	83,600
June 1989	36,100	72,000
September 1990	37,600	83,700
June 1991	37,500	83,400

4.1C2 Sociocultural Issues, Public Services, and Community Infrastructure

For purposes of this analysis, sociocultural issues include:

- traditional occupations
- social structure
- language
- family life
- other forms of cultural adaptation to the natural and human environment

Public services and community infrastructure, on the other hand, commonly include the following public, semipublic, and private services and facilities:

- education
- sewage treatment
- water supply
- transportation
- housing
- police and fire protection
- solid-waste disposal
- recreation
- health care
- other utilities

The following occurrences can affect social and cultural elements:

- changes in traditional occupation
- disruption in the viability of extant subcultures
- social and community dysfunction
- detrimental effects on individual or family life

Effects on public services and community infrastructure arise when the use rate of services significantly exceeds or falls below the capability of a local area to provide a satisfactory level of service.

The GOM Region funded one socioeconomic study, *Impact of Offshore Oil Exploration and Production on the Social Institutions of Coastal Louisiana*, currently undergoing draft review process. Five other MMS-funded studies were conducted pertaining to social or economic topics:

- Survey of Recreational Fishing at Platforms
- IXTOC I Oil Spill Economic Impact Study
- Socioeconomic Indicators of Gulf Oil and Gas Activity
- Socioeconomic Indicators of Gulf Oil and Gas Activity Phase 2
- Socioeconomic Impacts of Declining Outer Continental Shelf Oil and Gas Activities in the GOM

In addition, several symposia on socioeconomics and the natural gas and oil industry were held at the annual GOM Region Information Transfer Meetings.

In November 1992, an assessment (NRC, 1992) of MMS's social and economic studies by the National Academy of Sciences (NAS) found that no systematic program existed during 1987-1991 for identifying and analyzing important socioeconomic issues in the GOM Region. In response, the MMS funded a workshop, through the University Research Initiative, to recommend a social science research agenda for the MMS. This workshop is the first step in designing a systematic program for social sciences in the GOM Region and in addressing the problems identified in the NAS report.

Effects of OCS-Related Employment: Estimates of OCS-related employment in the GOM Region from 1987 through 1991 are found in table 4.1-4. Overall, the direct OCS-related employment declined by approximately 24 percent between 1987 and 1991.

The OCS extended work schedule (7 days on, 7 days off) allowed for part-time participation in more traditional occupations (fishing, trapping, etc). The relationship between OCS natural gas and oil activities and traditional culture in the coastal subareas of Louisiana has been mostly positive (Forsythe, 1992, written comm.). The extended work schedule changed the practice of traditional familial roles, in an adaptive response to absence. In the majority of cases, familial adaptations to the extended work schedule were successful. However, the inability of some families to cope with changing familial roles associated with the periodic absence of a spouse placed some demands on social service agencies for counseling and other forms of assistance.

During the decline of OCS natural gas and oil activity, stress from decreased family income and loss of security associated with OCS-related job layoffs affected family life. Demand for public services was greater between 1987 and 1989 than from 1989 to 1991. As the level of employment in OCS-related industry decreased, more persons engaged in traditional occupations (such as trapping and shrimping) to supplement their income. As well, the exodus of relatively high paying OCS-related jobs allowed small businesses to draw from a larger pool of potential employees; however, these jobs were generally lower paying than those associated with OCS activities. In fact, deleterious impacts to the family life occurred in pertinent individual cases as a result of relative income differences, particularly from 1987 to 1989 (Laska et al., 1993).

Conclusion: The large demand for public services between 1987 and 1989 resulted from the significant decline in OCS-related employment. The family life was affected as a result of fluctuations in OCS-related employment, particularly from 1987 to 1989.

Effects of OCS-Related Population Change: Total OCS-related population (table 4.1-4) decreased from 1987 through 1989, then increased slightly and stabilized through 1991. Labor force requirements of OCS natural gas and oil activities required little to no in-migration from 1987 through 1991. In OCS-related staging centers and administrative centers, out-migration from the overall decline in OCS-related population caused a drop in population growth rates and a loss of population. Family life was affected by the departure of extended family members, and there was some loss of cohesion within some of the communities that served as staging and administrative centers.

Conclusion: The decline in OCS-related population in 1987 through 1989 caused a greater demand for public services. Stresses on community infrastructure lessened as OCS-related population declined. Deleterious impacts to the family life occurred in pertinent individual cases as a result of fluctuations in OCS-related population and demographic change, particularly from 1987 to 1989.

4.1C3 Commercial Fisheries

The GOM provides nearly 40 percent of the commercial fish landings in the continental United States. During 1988, commercial landings of all fisheries in the Gulf totaled nearly 1.8 billion pounds, valued at about $649 million (USDOC, NOAA, NMFS, 1990a)—representing an 18 percent decrease in landings and a 7 percent decrease in value from 1987. Adverse weather, decreased effort, and possible declines in available stocks contributed to declines in landings. Also, the heavy freeze in late December 1989 affected all inshore species (USDOC, NOAA, NMFS, 1990b).

Effects of OCS Seismic Surveying: Seismic surveys are systematically executed, and any effects on fish resources constitute, at most, short-term avoidance behavior and do not adversely affect harvestable fish populations in the GOM. The sources of acoustical pulse used in seismic surveys are generated by air guns or water guns, which have little effect on even the most sensitive fish eggs at distances of 5 m from the discharge (Chamberlain, 1991; Falk and Lawrence, 1973). In general, the acoustical pulse from air guns or water guns has relatively little effect on marine invertebrates, presumably due to the invertebrates' lack of a swim bladder. Available scientific information concerning the effects of acoustic pulses from air guns and water guns on fish eggs and larvae indicates that commercial fishery resources are little disturbed by seismic surveying (Wingert, 1988).

Conclusion: Commercial fisheries were not affected by OCS-related seismic surveying conducted in the GOM from 1987 through 1991.

Effects of OCS Support Vessel Traffic: For the period 1987 through 1991, approximately 1 million helicopter trips (a trip being 1 takeoff and 1 landing), 440 barge trips, and 52,000 service vessel trips occurred annually in the GOM Region as a result of OCS-related activities. Offshore service vessels do not interfere with commercial fisheries because these vessels tie directly to platforms or to nearby sea buoys. Service vessels travel well established routes within shipping fairways and navigable waterways, and dock at special facilities that do not service the fishing fleet.

Conclusion: Commercial fisheries were not affected by OCS support vessel traffic in the GOM from 1987 through 1991.

Effects of NORM in OCS-Produced Formation Waters: See sections 3.4 Non-Routine Events and 4.1B3 Fish Resources for discussions on how NORM is formed and what effects, if any, NORM has on fish resources and, subsequently, on commercial fisheries. Numerous studies specific to the questions concerning NORM in the food chain and in seafood were initiated or completed since 1991 (Snavely, 1989; Hamilton et al., 1992; and Mulino, 1992). Results and available information from these investigations will be discussed in the next 20(e) report.

Data collected from offshore platforms discharging NORM in formation waters show that epifaunal and associated organisms within 3 m of the discharge do not accumulate radium at high levels (Mulino and Rayle, 1992). The levels of radioactivity measured in soft tissue and hard parts of all biota tested (barnacles, mollusks, fish, blue crabs) were near the lower limit of detection. Any radium concentrations above this lower limit were in inedible hard parts (shell or bone).

A 1990 investigation concerning the health risk for radium in seafood harvested near outfalls of onshore formation waters was performed by Hamilton et al. (1992). The study concluded that the health risks associated with the discharge of produced formation waters containing radium are comparable to those expected to result from background concentrations of radium in Louisiana coastal waters. The authors state that they were purposely conservative and overestimated the concentration of radium in fish and shellfish and overestimated the amount of seafood harvested near outfalls. In addition, the authors used EPA risk factors that they believed overestimated the health risks associated with small amounts of radium.

Conclusion: The likelihood of consuming seafood available for commercial harvest that contains higher than normal radium levels was minimal. The prospect that NORM discharged in offshore formation waters affected commercial fishery species and subsequently increased human intake of radium was virtually none.

Effects of OCS Platform/Structure Emplacement and/or Removal: During 1987 through 1991, 802 OCS platforms were installed and 448 OCS platforms were removed in the GOM. The emplacement of a production platform in about 60 m of water, with a surrounding 100-m navigational safety zone, results in the loss of approximately 6 ha of bottom trawling area to commercial trawl fishermen. In addition, GOM fishermen experienced some economic loss from gear conflicts; however, the economic loss for a fiscal year, historically, has been less than 1 percent of the value of that same fiscal year's commercial fisheries landings. Most financial losses from gear conflicts were covered by the Fishermen's Contingency Fund, as shown below.

Table 4.1-5 Fishermen's Contingency Fund Claims in the Gulf of Mexico Region, 1987 through 1991

Fiscal Year	Number of Claims	Percent Approved	Total Paid
1987	127	85	$612,993
1988	123	87	$595,730
1989	172	86	$783,372
1990	198	77	$836,799
1991	128	91	$511,947

The presence of offshore structures can also benefit commercial fisheries. During the period 1987 through 1991, an average of 3,800 platforms operated throughout the GOM, extending from offshore Alabama to the southern reaches of Texas. The areas occupied by platforms constitute over 28 percent of the hard substrate found in this otherwise soft bottom environment (Gallaway, 1984; Stanley et al., 1991). Due to the limited amount of hard bottom substrate in the offshore waters from Mississippi to Texas, the expansion of the natural gas and oil industry provided a significant proportion of the habitat for organisms dependent on hard substrate and commercial fishery resources that are structure-related, such as snapper and grouper (Gallaway and Lewbel, 1982). Natural gas and oil platforms in the GOM are popular fishing destinations for both sport and commercial fishermen, thus providing evidence of their effectiveness as artificial reefs (Stanley and Wilson, 1989).

However, platform removal can cause adverse effects on commercial fisheries. The MMS requires lessees to remove all structures and underwater obstructions from their leases in the Federal OCS within 1 year of the lease's relinquishment or termination of production. Lessees removed 448 of these structures from the GOM during 1987 through 1991. Eighty percent of multi-leg platforms in water depths less than 156 m are removed by severing their pilings with explosives placed 5 m below the seafloor. The resulting concussive force is lethal to fish that have internal air chambers (swim bladders), are demersal, or are in close association with the platform being removed (Scarborough-Bull and Kendall, 1992; Young, 1991). Within the past decade, stocks of reef fish have declined in the GOM. There is concern over a possible connection between this decline and the explosive removal of platforms. To examine this issue, the MMS entered into a formal Interagency Agreement with the NOAA to investigate fish mortality associated with removal of OCS structures. This study will attempt to relate the role of fish mortality from platform removals to the status of reef fish stocks in the GOM (USDOI, MMS, 1990d).

Conclusion: During 1987 through 1991, limited local impacts on commercial fisheries occurred as a result of platform emplacement because the areas occupied by platforms were no longer accessible to trawl fishermen. Also, the concussive force associated with platform removal killed nearby demersal fish, and the removal of platforms eliminated hard substrate habitat. However, platforms also provided habitat (hard substrate) not usually found in the soft bottom environment of the Gulf of Mexico.

Effects of OCS Pipeline Construction: In the GOM Region, from 1987 through 1991, 3,665 miles of pipeline were laid. Gear conflicts from underwater OCS obstructions (such as pipelines) cause loss of trawls and shrimp catch, business downtime, and vessel damage to commercial fisheries. However, all pipelines in water depths less than 69 m (200 ft) are buried, and their locations are made public (Alpert, 1990). Spatial loss from construction is temporary.

Boesch and Robilliard (1985) reviewed the potential effects on coastal habitats from OCS natural gas and oil activities. In this report, pipelines are one of the causes of long-term damage to wetlands. Since approximately 92 percent of commercially important fish species are estuarine, the loss of GOM wetlands as nursery areas is a threat to the commercial fishing industry (Angelovic, written comm., 1989; Christmas et al., 1988; EPA, 1989). However, most loss of wetland nursery areas is from channelization, river control, and subsidence of wetlands (Turner and Cahoon, 1987). Turner and Cahoon (1987) found that OCS activities were directly responsible for only 4 percent of the loss of commercial fish nursery areas.

Conclusion: OCS pipeline construction activities temporarily affected commercial fisheries in the GOM, but OCS pipelines did not significantly affect commercial fisheries from 1987 through 1991.

Effects of OCS Oil Spills: During the period 1987 through 1991, three large OCS-related pipeline spills ($\geq$1,000 bbl) occurred in the GOM (see table 3.4-2).

These spills originated 30-70 miles offshore. There were also 163 small (>1-999 bbl) spills, averaging 12 bbl.

The effects and extent of damage from an oil spill to commercial fisheries are restricted by time and location. Oil spills that contact coastal bays, estuaries, and OCS waters have the greatest effect on commercial fishery resources when pelagic eggs and larvae are present. Oil spills that contact nearshore open waters could impact migratory species, such as mackerel, cobia, and crevalle. An oil spill contacting a low-energy inshore area affects localized populations of commercial fishery resources such as menhaden, shrimp, and blue crabs. Chronic oiling in an inshore area affects all life stages of a localized population of a sessile fishery resource such as oysters. However, concerns about the possible impact of spilled oil on the breeding cycle of commercial fishery resources have proven to be false (Oil Spill Intelligence Report, 1991; Baker et. al., 1991).

Fish produce eggs on an enormous scale; the overwhelming majority of these eggs die at an early stage, generally as food for predators. Even a heavy mortality from an oil spill has no detectable effect on an adult population that is exploited by a commercial fishery. This has been confirmed during and after the *Torrey Canyon* spill off southwest England and the *Argo Merchant* spill off Nantucket, Massachusetts. In both cases, a 90-percent mortality of pilchard and pollack eggs and larvae was observed in the affected area, but this mortality rate had no impact on the regional commercial fishery (Baker et al., 1991).

Development abnormalities in juveniles occur naturally in wild fish populations, and the frequency of these abnormalities is increased in populations chronically exposed to oil. These abnormal fish do not survive long. However, like the effects from mortality immediately following an oil spill, delayed mortality has a negligible effect on commercial fisheries.

For OCS-related oil spills to affect a commercial fishery resource, whether estuary-dependent or not, eggs and larvae would have to be abnormally concentrated in the immediate spill area. Oil components also must be present in highly toxic concentrations when both eggs and larvae are in the pelagic stage (Longwell, 1977).

Conclusion: Despite possible impacts, no significant cumulative effects from OCS-related spills on commercial fisheries were documented in the GOM Region during this period.

4.1C4 Recreation and Tourism

Coastal recreational activities popular in the GOM include swimming, fishing, scuba diving, beach use, sunbathing, windsurfing, birdwatching, shelling, and hunting. Major State and Federal parks, wildlife refuges and management areas, and local recreation areas cover large expanses of the coastline and many of the barrier islands. Tourism is a major component of many coastal economies, regionally estimated in billions of dollars and millions of people. Potential effects to recreation and tourism may result from activities that cause visual effects, land-use conflicts, and oil-spill impacts.

Effects of OCS Platform/Structure Emplacement and/or Removal: The emplacement of platforms can adversely affect the aesthetic nature of the coastline when constructed close enough to shore to be seen and to obscure a relatively large portion of the natural environment (Nassauer and Benner, 1982). However, these same structures function as high profile artificial reefs attracting both fish and fishermen. The GOM contains the largest concentration of offshore platforms in the United States (3,800 in Federal waters alone). Approximately 230 large platforms are located in State and Federal waters in sight of the Louisiana coast, and approximately 50 are located within view of the Texas coast. In addition, several clusters consisting of numerous small platforms are found in view of the Louisiana and Texas coasts. Approximately one-half of the structures visible from shore are in Federal waters off the coast of Louisiana. Only in recent years have natural gas and oil drilling operations been visible in nearshore waters off the coasts of Mississippi and Alabama.

Three studies examined the impact of these sights from the coast (Nassauer and Benner, 1982; Dornbusch and Company et al., 1987; Kearney, 1991). These studies showed that visitors most disliked nearby facilities that obstructed the view of the natural environment, and facilities or structures at any distance that were not neat and clean. No data were collected to indicate whether the residents, businesses, or visitors to the GOM coastal areas have changed their coastal recreational patterns, other than fishing, because of the sight of offshore structures.

Platforms located near the coast offer beneficial impacts to recreational diving and fishing. Roberts and Thompson (1983) demonstrated that scuba divers in Louisiana were willing to pay considerable sums for the unique opportunity of diving around offshore natural gas and oil structures. According to the NMFS's Marine Recreational Fishing Statistics Survey, an estimated 400,000 fishing trips were made to GOM petroleum platforms in 1989 (Sports Fishing Institute, 1992).

Platforms in State and Federal waters serve as navigational aids and even refuges in storms. For a long time, recreational fishermen have been attracted to these platforms. Platforms act as a reef in the ocean, attracting numerous species of fish—many of these species are of interest to recreational and commercial fishermen. The NMFS determined that up to 70 percent of all recreational fishing offshore Louisiana was directly associated with petroleum structures (Witzig, 1986). Most recreational fishing and scuba diving around petroleum structures take place within 20 miles of shore (Ditton and Auyong, 1984). However, expanding deep-water natural gas and oil operations are attracting some GOM fishermen to areas located 25 to over 100 miles from shore. Hence, the construction of large numbers of platforms off the coasts of Louisiana and Texas has led to a substantial growth in offshore recreational fishing, which has benefited recreation and tourism in the coastal zone of these States.

Since the platforms nearest the coasts were generally sited earliest—over 40 years ago—many are now being removed. Removing those platforms reduces the number available for recreational fishing, thereby reducing the beneficial cumulative impact on that activity. The construction of permitted artificial reefs replaces some of the 100 production platforms removed annually off the Louisiana and Texas coasts. Over the last 5 years, almost 40 obsolete petroleum structures have been converted into designated artificial reefs by the GOM States.

Conclusion: Despite any aesthetic effects, OCS natural gas and oil development in the GOM continued to stimulate, expand, and enhance offshore recreational fishing off the Texas and Louisiana coasts during the period 1987 through 1991.

Effects of OCS-Related Trash and Debris: Some of the trash washed up on coastal beaches in Texas and Louisiana comes from OCS natural gas and oil activities. The proportions attributed to the various marine industries (shipping, fishing, military activities, boating, and petroleum) are indeterminable—however, there is ample evidence to implicate all user groups as contributors to the cumulative problem. Significant strides are being made to improve waste handling and disposal practices within the natural gas and oil industry through the efforts and encouragement of the Texas General Lands Office, the MMS, the EPA, private conservation groups, and natural gas and oil operators.

Results of the annual "Take Pride Gulf-wide" beach cleanup estimate that, on average, 1 ton of trash and debris is removed per mile by citizen volunteers along Texas and Louisiana coastal beaches each year during the fall cleanup (Center for Marine Conservation, 1992). Two ongoing scientific surveys are assessing trash and litter trends affecting GOM coastal beaches. Preliminary results from the MMS-supported investigation of marine debris impacting Mustang Island beaches over the last 2 years indicate a detectable reduction in most large trash items associated with man's use of the GOM. However, small items or "microtrash" has shown an increase over this same time period, which coincides with the implementation of new international prohibitions and restrictions on offshore garbage disposal (Amos, 1992). With the exception of hard hats, pallets, and plastic strapping, debris items generally associated with the oil industry have shown a decline since 1989 at Mustang Island.

Summary results from systematic surveys of marine debris inventoried in national parks associated with GOM coastal beaches in Texas (Padre Island National Seashore) and Mississippi and Florida (Gulf Islands National Seashore) show average accumulation rates going up over the last 3 years (Cole et al., 1992). During the 1991 survey, beaches at Gulf Island National Seashore had a mean quarterly accumulation rate of 803 items/km. With an average quarterly accumulation rate of 22,476 debris items/km, Padre Island National Seashore has the dubious recognition as the most littered beach in the nation. No attempt has been made in the National Park Service survey program to isolate specific trends associated with debris items believed to be coming directly from offshore natural gas and oil operations. However, special tracking of 55-gallon drums has shown a marked decline of this debris item in recent years at Padre Island National Seashore.

In addition, many plans and regulations were implemented to reduce marine debris, including the following:

- The natural gas and oil industry, through the Offshore Operators Committee, has mounted an intensive campaign to eliminate trash generated by its operations and those of its subcontractors (Herbert and Foreman, 1992). In addition, MMS regulations (30 CFR 250.40) prohibit the discharge of trash and other solid waste materials associated with OCS operations.

- In 1991, through the EPA's Gulf of Mexico Program, a regional Marine Debris Action Plan was developed and endorsed by public and private interest groups. Implementation of this plan should lead to the enhancement of the coastal recreation environment in the next few years.

- The MMS prohibits the disposal of OCS equipment, containers, and other materials into offshore waters by lessees (30 CFR 250.40). In addition, MARPOL Annex V, Public Law 100-220 (101 Statute 1458), prohibits the disposal of any plastics at sea or in coastal waters. The OCS lessee's/operator's adherence to MMS policy and MARPOL regulations served to reduce disposal of OCS-related plastic debris into the waters of the GOM.

Conclusion: During the period 1987 through 1991, OCS-related activities continued to contribute to marine debris impacts on Texas and Louisiana beaches. However, new legal restrictions on offshore garbage disposal, regional plans, anti-litter programs, and industry initiatives have decreased and should further decrease future natural gas and oil debris effects on GOM coastal beaches.

Effects of OCS Oil Spills: Three large OCS-related pipeline spills (see table 3.4-2) and 163 small (>1-999 bbl) OCS oil spills (averaging 12 bbl) occurred in the GOM during 1987 through 1991. The large pipeline spills originated 30-70 miles offshore.

Oil spills reaching coastal recreational areas affect aesthetics and recreation by coating beaches and temporarily make them unsuitable for recreational use. This effect can result in reduced economic intake for local recreation-oriented businesses. The loss is usually immediate but does not extend beyond the removal of the oil and fouled coastal land base (Restrepo et al., 1982).

Conclusion: Although OCS oil spills occurred in the GOM during 1987 through 1991, no impacts on coastal recreation and tourism from these spills were recorded.

4.1C5 Archaeological Resources

Archaeological resources in the GOM include historic shipwrecks and submerged prehistoric sites. Natural gas and oil exploration and production activities have the potential to affect both prehistoric and historic archaeological resources on the OCS.

Dredging, anchoring, and siting drilling rigs, production platforms, and pipelines could destroy artifacts or disrupt the provenience and stratigraphic context of artifacts, sediments, and paleoindicators. Oil spills could destroy the ability to date prehistoric sites by radiocarbon dating techniques. Ferromagnetic debris associated with OCS natural gas and oil activities would tend to mask magnetic signatures of significant historic archaeological resources.

Four studies were funded in an effort to minimize impacts to archaeological resources in the GOM Region (Coastal Environments, Inc., 1977, 1982, 1986; Garrison et al., 1989). The studies have developed predictive models to identify areas of the OCS where there is a high probability for the occurrence of archaeological resources. These studies are periodically updated using archaeological, geological, and geophysical information generated since the preparation of the original study (or last update).

The Archaeological Resource Stipulation (established in 1973) requires the lessee to conduct lease-specific archaeological resource surveys in those areas having a high potential for archaeological resources. If a potential archaeological resource is identified, the operator is required to avoid the potential resource or to conduct additional studies to determine its significance. Where possible, all operators have chosen to avoid the potential resources identified.

Effects of OCS Drilling: From 1987 through 1991 in the GOM Region, there were an average of 2,209 exploration wells and 2,005 development wells drilled on the OCS. The location of any proposed activity within a lease block that has a high probability for the occurrence of historic shipwrecks or submerged prehistoric archaeological sites requires archaeological clearance prior to operations. That clearance is based on an analysis of remote-sensing survey data required by the Archaeological Resource Stipulation.

Conclusion: OCS drilling activities in the GOM between 1987 and 1991 did not affect historic shipwrecks or prehistoric archaeological sites on the OCS.

Effects of OCS Pipeline Emplacement: During 1987 through 1991, 3,665 miles of pipelines were laid in the GOM. A portion of this total was laid in areas having a high probability for the occurrence of archaeological resources; however, this emplacement had no adverse effects on these resources. Pipelines laid within these areas must have archaeological clearance prior to construction operations.

Conclusion: There were no effects on historic shipwrecks or prehistoric archaeological sites on the OCS as a result of OCS pipeline emplacement in the GOM OCS between 1987 and 1991.

Effects of OCS-Related Dredging Activities: Waterways accessing the OCS in the GOM Region periodically require dredging to ensure access for deep draft vessels. All navigational channels are outside of MMS jurisdiction since they lie within State-controlled waters. The COE is responsible for ensuring compliance with all pertinent archaeological laws and regulations pertaining to these waterways. Impacts by dredging activities to a historic shipwreck, the *Santa Maria de Yciar*, in the Port Mansfield entrance channel have been documented (Espey, Huston, & Associates, 1990). The percentage of OCS-related natural gas and oil activity usage of this particular channel is negligible (table 4-15, USDOI, MMS, 1992c).

Conclusion: Although there were reported impacts to a historic shipwreck from maintenance dredging of the Port Mansfield entrance channel, the percentage of OCS natural gas- and oil-related use of this channel is negligible.

Effects of OCS Platform/Structure Emplacement and/or Removal: In the GOM from 1987 through 1991, 802 OCS platforms were installed, and 448 were removed. Some of these was installed within areas having a high probability for the occurrence of archaeological resources. All platform installations in these areas must have archaeological clearance as required by the Archaeological Resource Stipulation. Platform removals did not impact archaeological resources because an archaeological clearance was required prior to platform installation.

Conclusion: There were no effects to archaeological resources as a result of OCS platform installation and/or removal in the GOM from 1987 through 1991.

Effects of OCS Ferromagnetic Debris: The OCS natural gas and oil activities in the GOM from 1987 through 1991 included drilling 2,209 exploration wells and 2,005 development wells, installing 802 OCS platforms, and laying 3,665 miles of pipelines. Archaeological clearance of these operations protected historic shipwrecks from impacts.

Ferromagnetic debris related to OCS exploration and development activities can mask magnetic signatures of historic shipwrecks. An MMS-funded study (Garrison et al., 1989) found an increase in ferromagnetic materials on the seafloor in OCS blocks on which natural gas and oil activities occurred. The change of survey linespacing (from 150 to 50 m) in areas having a high probability for historic shipwrecks provides better data, which are necessary for clearance of OCS operations.

Surveying lease blocks (with high potential for historic shipwrecks) prior to OCS operations provided the MMS with baseline information on seafloor objects before the OCS natural gas- and oil-associated ferromagnetic debris was introduced. Using this baseline information resolved the problem of masking the magnetic signatures of historic shipwrecks.

Conclusion: Because the archaeological stipulation precluded OCS-related bottom disturbing activities in areas of archeological resource potential, adverse effects from the OCS factors were prevented.

Effects of OCS Oil Spills: During the period 1987 through 1991, three large ($\geq$1,000 bbl—see table 3.4-2) OCS-related pipeline spills and 163 smaller (>1-999 bbl) OCS platform and pipeline spills (totaling 1,987 bbl) occurred in the GOM. The large pipeline spills originated 30-70 miles offshore.

Conclusion: The OCS-related oil spills that occurred in the GOM from 1987 through 1991 did not contact submerged prehistoric sites located beneath the seafloor, and there were no reported effects to historic shipwrecks from these spills.

4.2 Pacific Region

The Pacific Region is divided into four planning areas: Southern California, Central California, Northern California, and Washington/Oregon (fig.4.2-1). More detailed information relating to the OCS Program can be found in *Pacific Summary Report/Index, (November 1984 - February 1986)* (Risotto and Rudolph, 1986). No lease sales were held in the Pacific Region between 1987 and 1991.

Postlease activities took place in the Southern California Planning Area between 1987 and 1991 (see fig. 4.2-2). During the 5 years covered by this report, the following OCS-related activities and associated discharges occurred in the Pacific Region:

- 119 wells were drilled: 12 exploration and 107 development wells
- over 152 MMbbl of crude oil and condensate were produced
- over 257,000 million cubic feet of natural gas were produced
- 3 OCS structures were installed: 1 platform and 2 jackets
- 29 line miles of OCS pipelines were constructed
- 187 bbl of OCS crude oil and condensate were spilled
- 390,000 bbl of drilling muds were discharged
- 200,000 bbl of drill cuttings were discharged
- 210,000 bbl of produced formation waters were discharged

4.2A Physical Environment

4.2A1 Water Quality

From 1987 through 1991, there were 57 OCS G&G permits issued (see table 4.2-1).

Table 4.2-1 OCS G&G Permits Issued by the Pacific Region, 1987 through 1991*

Year	Number
1987	20
1988	33
1989	0
1990	4
1991	0
Total	**57**

* All permits issued were for projects offshore California.
Source: *Federal Offshore Statistics: 1991* (USDOI, MMS, 1992a)

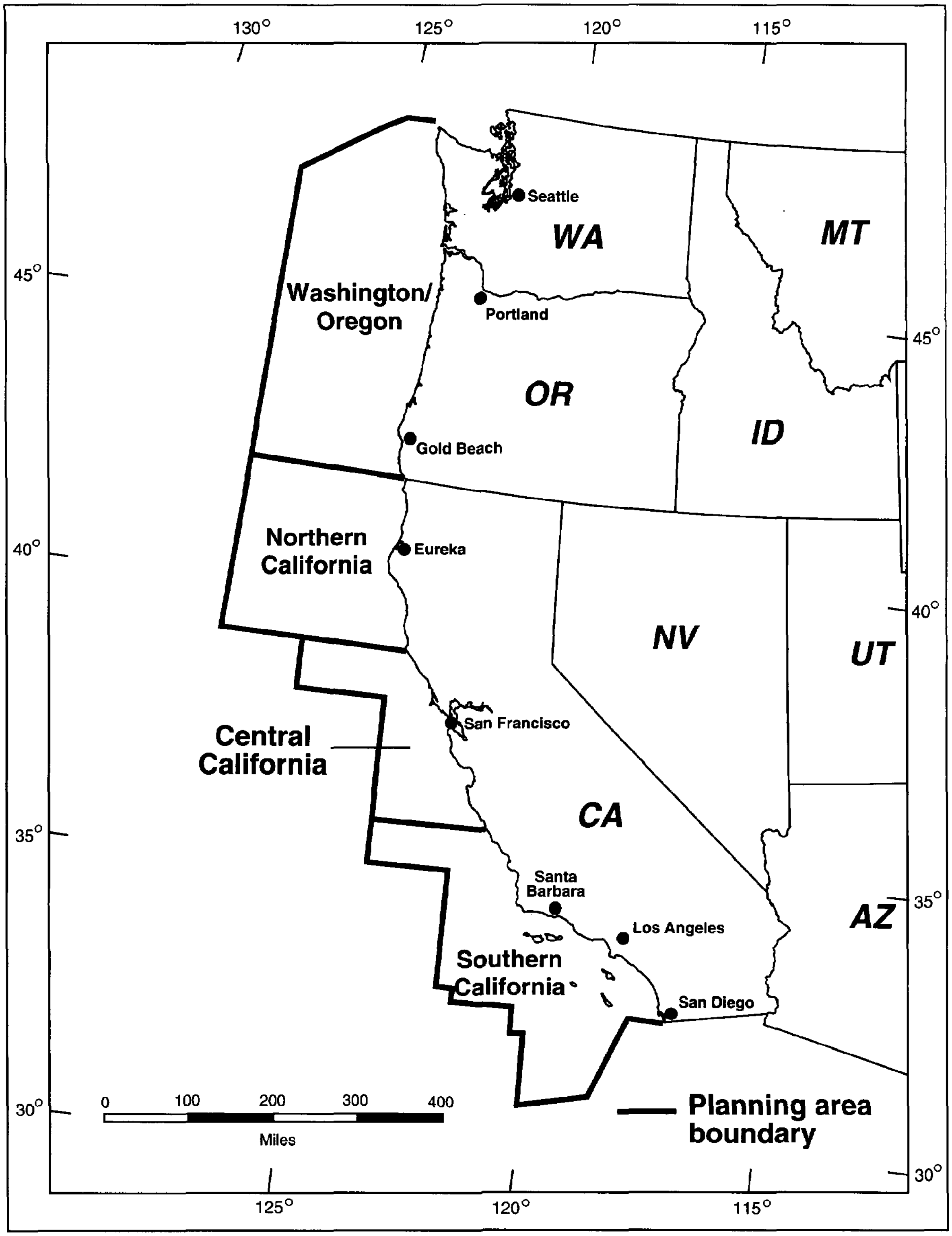


Figure 4.2-1. Pacific OCS Planning Areas

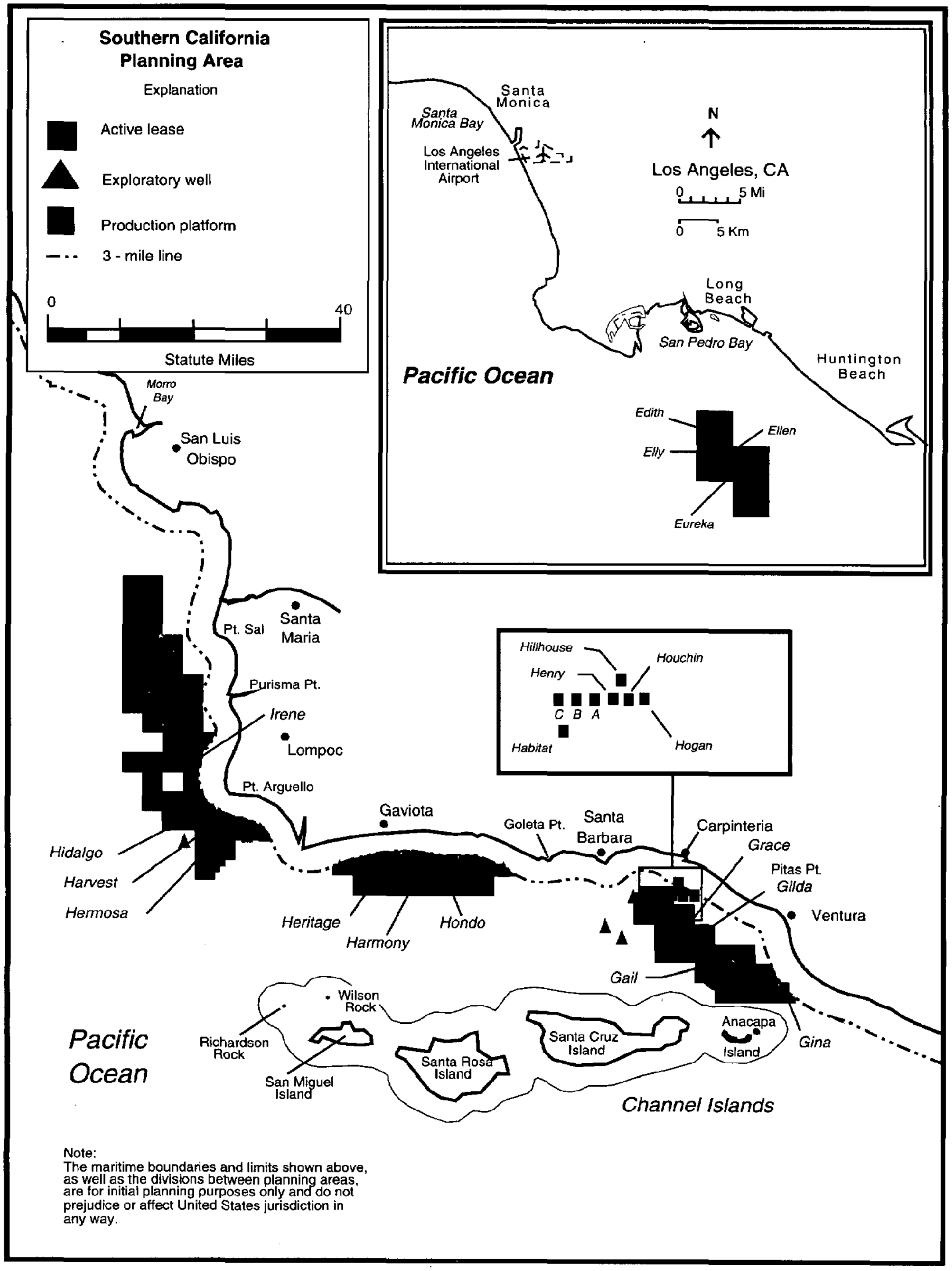


Figure 4.2-2. Southern California Planning Area, Status of Leases and Exploration and Production Activities, 1987 through 1991

Effects of OCS Geological Sampling: Geological sampling activities in the Pacific Region have been limited: only 13 geological sampling permits were issued.

Water quality around the immediate sampling site is altered and degraded in several ways during geological sampling activities. Bottom sampling and shallow coring cause minor sediment suspension and an associated increase in turbidity. Deep stratigraphic testing, being similar to rotary drilling of exploratory wells, results in the additional discharge of small amounts of drilling muds and cuttings and in the associated increase in levels of suspended solids and trace metals in the receiving water. (These effects are discussed further below.) However, the effects on water quality resulting from bottom sampling and coring activities are limited to a few tens of meters within the immediate area of operation (USDOI, U.S. Geological Survey [USGS], 1976).

Conclusion: Given the small amount of geological sampling conducted in the Pacific Region from 1987 through 1991 and the temporary and localized nature of the effects associated with bottom sampling and coring, no significant cumulative effects on water quality occurred as a result of geological sampling during this period.

Effects of Offshore Discharge of OCS Muds and Cuttings: From 1987 through 1991, approximately 390,000 bbl of drilling muds and 200,000 bbl of cuttings were discharged in the Pacific Region as a result of drilling 12 exploratory wells and 107 development wells. Nearly 90 percent of the OCS drilling activity in the Pacific Region and, in turn, the discharge of muds and cuttings occurred in the Santa Barbara Channel and Santa Maria Basin.

When discharged into the surrounding waters, drilling muds and cuttings may create detectable turbidity plumes several thousand meters long. Near the discharge site, benthic infauna may be affected by smothering as the plume settles and by change of bottom sediment characteristics. However, dilution is extremely rapid in offshore waters; drilling fluids discharged into the ocean are usually diluted to very low concentrations within 1,000-2,000 m downcurrent from the discharge point (Ayers et al., 1980a, b; ECOMAR, Inc., 1978, 1983; Houghton et al., 1980; Northern Technical Services, 1983; Neff, 1987).

Suspended solids associated with these discharges may cause mortality or deleterious effects in sensitive species and juveniles in the water column. Generally, experts believe that suspended solid levels and metal concentrations return to background levels once they are 1,000-2,000 m from the discharge site (ECOMAR, Inc., 1980; NRC, 1983). However, in a field study of drilling fluids from an exploratory well in the Santa Barbara Channel, Jenkins et al. (1989) found sediment concentrations of barium to be above background levels as far as 2,500 m downcurrent from the well. They also observed statistically significant increases in the bioaccumulation of barium in two species of marine invertebrates at stations as far as 1,500 m from the well, but they concluded that the soluble form of the element was not present in sufficient quantities to cause toxicity. Similarly, Neff, Hillman et al. (1989), who conducted laboratory tests of trace metal bioaccumulation by several species of marine invertebrates, concluded that metals associated with drilling mud barite are virtually unavailable to marine organisms.

The California OCS Phase II Monitoring Program (CAMP II) was a 5-year, multidisciplinary study designed to monitor potential environmental changes resulting from natural gas and oil development in the Santa Maria Basin (Battelle Ocean Sciences, 1991). In the course of this study, drilling discharges were monitored in the vicinity of Platform Hidalgo in 1987 and 1988. Barium concentrations in sediments increased within several kilometers of the platform during this period, but decreased following termination of drilling. Although increased levels of petroleum hydrocarbons were observed at Platform Hidalgo, it was unclear whether this increase was due to drilling discharges or natural oil seeps.

Peak fluxes of 400-500 mg/m^2/day of drilling solids were measured within 1.5 km of Platform Hidalgo, and 4 of 22 hard-bottom invertebrate taxa showed significant reductions in mean abundances at high-flux stations after drilling began. However, the concentrations of chemical contaminants in suspended particles associated with the drilling discharges were below toxic levels. This observation suggested that any biological changes due to the drilling muds were related to physical effects of the increased particle loading.

CAMP III, which is currently under way, will continue monitoring hard-bottom organisms near drilling activities in the Santa Maria Basin for 3 years. This study will provide information that can be used to separate natural background variation from potential low-level cumulative effects of OCS drilling activities.

As the result of a Memorandum of Agreement with EPA Region 9, the MMS has conducted compliance monitoring of California OCS natural gas and oil facilities on behalf of EPA since 1990. The MMS inspects records and collects produced water samples at all OCS facilities off California that discharge these effluents into the marine environment. The EPA conducts the laboratory analysis of the samples and is responsible for any necessary enforcement if violations are discovered. Prior to any mud dumps, the MMS also collects samples to be tested for biotoxicity.

Because of dilution, dispersion, and settling, the effects of drilling muds and cuttings on water quality are limited to the immediate vicinity of the discharge and are generally not detectable beyond 2,000 m from the discharge. The accumulation of trace metals and hydrocarbons in area waters due to periodic releases of drilling muds and cuttings is unlikely.

Conclusion: Although localized effects were detected, no significant cumulative effects on water quality in the Pacific Region were identified as a result of the discharge of drilling muds and cuttings.

Effects of Construction of OCS-Related Onshore Facilities: One onshore construction project occurred in the Pacific Region from 1987 through 1991. In 1988, Exxon began construction of a separation, treatment, and gas processing plant at Las Flores Canyon/Corral Creek in Santa Barbara County as part of their Santa Ynez Unit (SYU) project.

The New England River Basin Commission (1976) reviewed the procedures and environmental impacts related to OCS onshore facility construction. The authors claim that land clearing and earth movement during construction promote surface runoff containing elevated levels of suspended solids (organic and inorganic) and possibly heavy metals. This runoff may affect nearby streams and rivers; however, these effects are limited by erosion and runoff control procedures employed during construction. Adverse effects on water quality are temporary and localized.

The effects on ground and surface water quality from onshore construction in the Pacific Region were addressed in various EIS's or reports (e.g., Arthur D. Little [ADL], 1985; URS Company, 1986) in response to Federal and State requirements. Permit conditions of the final DPP for the SYU project required the implementation of an Environmental Quality Assurance Program. This program was designed to ensure that the project complied with permit conditions pertaining to environmental protection and public concern. Permit compliance was monitored by the Santa Barbara County Resource Management Department. In relation to possible degradation of water quality, erosion and siltation control measures were applied to bluff-top areas and along Corral Creek; these measures were maintained throughout the construction period. The surface water quality of Corral Creek was monitored on a regular basis. Remedial measures were taken to recover soil stockpiles and to remove trench spoils from the Corral Creek mouth, and mitigation efforts were judged effective (ERC Environmental and Energy Services Co., 1991).

Conclusion: The final compliance report for the project (ERC Environmental and Energy Services Co., 1991) indicated no significant cumulative effects on water quality in the Pacific Region from the construction of the Las Flores Canyon gas processing plant—the only OCS-related onshore facility constructed during this report period.

Effects of Offshore Discharge of OCS-Produced Formation Waters: An estimated 210,000 bbl of produced formation water were discharged from OCS activities in the Pacific Region from 1987 through 1991—an average of 42,000 bbl per year. At present in the Pacific Region, produced water is discharged into the ocean only in the Santa Barbara Channel. Produced water from platforms in the Santa Maria Basin is shipped to shore and disposed of in onshore wells; produced formation water from platforms off Long Beach is disposed of in waterflood and disposal wells.

Although the harmful components of produced water (such as petroleum hydrocarbons and trace metals) accumulate in surface sediments near the discharge point, they remain in the water column for relatively short periods (Armstrong et al., 1979; Grahl-Nielsen et al., 1979; Middleditch, 1981b). The distance required to reach background levels varies depending on the volume and characteristics of each discharge, but mixing and dilution are very rapid after discharge. Produced water is considered to be only mildly toxic (Neff, 1987) since its water-soluble components are believed to dilute rapidly to levels well below those suspected to cause significant biological responses, based on laboratory tests (Montalvo and Brady, 1979; Middleditch, 1981b; Rose and Ward, 1981; Payne et al., 1987).

Conclusion: Currently, it is possible to conclude that only minor and localized effects on water quality resulted from the discharge of produced water into the Santa Barbara Channel from 1987 through 1991. These poorly defined effects were limited to the immediate vicinity of continuous produced water discharge points.

Effects of OCS Pipeline Construction: Approximately 29 line miles (46 km) of pipeline were constructed from 1987 through 1991 in the southern Santa Maria Basin and the Santa Barbara Channel.

During pipeline construction, resuspension of bottom sediments occurs because of trenching and placement of equipment on the seafloor. These activities cause an increase in turbidity and result in a decrease in sunlight penetration if the resuspended plume reaches the photic layer (from the surface to 30-100 m deep depending on the local, natural turbidity conditions). The magnitude of the sediment displacement depends on the sediment type, grain size, direction and strength of the prevailing currents, and the duration of the instigating activity.

The Conditions of Approval for pipeline and power cable installation in the SYU specified that Exxon use offshore installation techniques that minimize turbidity and dynamically positioned vessels to lay all pipelines and power cables from platform to shore. Exxon's use of these vessels involved about 22 anchor settings and retrievals in Federal waters. This use resulted in a reduction of 200-300 anchoring events compared to operations involving standard lay barges. Consequently, there was a proportional decrease in the levels of turbidity from resuspended sediments (USDOI, MMS, 1991b). Pipelaying activities were monitored by MMS inspectors throughout the construction period.

The MMS regulations also require that newly installed pipelines be hydrostatically pressure tested to verify their integrity. These tests are conducted by the operators and monitored by the MMS. Samples of hydrotest water discharges are collected and transported to an EPA-approved laboratory for analysis to ensure that NPDES permit conditions are being met.

To reduce the danger of rupture during earthquakes, pipelines installed on the OCS in the Pacific Region have not been buried. The amount of turbidity created during pipeline construction is, therefore, much more limited than in regions where pipelines are commonly buried. The only mechanical burial along the route occurs when the pipeline traverses the intertidal zone, and onshore. Thus, suspended sediment associated with the pipeline construction is limited and settles rapidly.

Conclusion: Although some temporary and localized increases in turbidity occurred from the construction of offshore pipelines in the Pacific Region during 1987 through 1991, no significant cumulative effects to water quality from this construction were identified.

Effects of OCS Oil Spills: From 1987 through 1991, 15 OCS-related oil spills (> 1 bbl) were recorded in the Pacific Region. These spills totaled 187 bbl of oil, for an average of 37.4 bbl per year. The largest single spill, 100 bbl, occurred on Platform Habitat when the crew was changing over the drilling fluid and inadvertently repositioned the wrong valve allowing drilling mud, laden with mineral oil, to be pumped into the ocean. Another spill of 50 bbl occurred when a workboat snagged a pipeline near Platform Gina in the eastern Santa Barbara Channel while grappling for an anchor chain buoy. The remaining 13 spills occurred at platforms and ranged in volume between 1 and 10 bbl.

The severity of an oil-spill effect on water quality depends on a number of factors, such as the following:

- type of oil
- location
- season
- weather and sea conditions

In the open ocean and in moderate to high seas, spills are dispersed and weathered by physical and biological processes such as evaporation, oxidation, emulsification, and uptake and metabolism by marine organisms. In areas contacted directly by a spill, before weathering has been completed, parameters such as oil and grease, trace metals, dissolved oxygen, hydrocarbons, BOD, and turbidity change by several orders of magnitude. Hydrocarbon levels within affected areas may be elevated up to 100+ μg/l (Fiest and Boehm, 1980). Much of the oil is dispersed throughout the water column over several days to weeks.

Greater effects could occur if a spill contacts a sensitive nearshore area, where oil may become entrained in suspended particles and bottom sediments. Compared to offshore areas, the water quality in enclosed embayments and estuaries would be more highly affected, since the weathering processes and the wind and sea state are generally much less severe. In addition, the BOD would be proportionally higher, as would toxic compound levels, while light transmittance levels would be decreased.

Each offshore facility in the Pacific Region is required to maintain on-site, oil-spill cleanup equipment that is capable of cleaning up small spills quickly. Periodic drills monitored by the MMS test the readiness of personnel and equipment to respond to a spill at a facility. Cleanup help is also available from response vessels stationed in San Luis Bay, in the Point Conception area; at Santa Barbara by the Clean Seas oil-spill cooperative; and in the Los Angeles/Long Beach Harbor by the Clean Coastal Waters cooperative.

The MMS conducts regular inspections of all offshore facilities and has issued INC's to operators even for small spills. As a result of its accident investigation of the Platform Gina oil spill described above, the MMS issued an NTL and other actions designed to reduce the likelihood of such a spill reoccurring.

Conclusion: All the OCS crude oil spills recorded in the Pacific Region from 1987 through 1991 were small. With the exception of a single 50-bbl pipeline spill and one 100-bbl platform spill, the spills averaged less than 3 bbl. For comparison, natural seeps in the Santa Barbara Channel have been estimated to introduce 40 to 670 bbl of oil into the marine environment per day (Fischer, 1978), and about 1 bbl of oil per day seeps into the Channel as a result of the Santa Barbara 1969 spill (USDOI, MMS, 1988a). All the OCS-related spills from 1987 through 1991 were quickly cleaned up, and no significant effects on water quality were observed.

4.2A2 Air Quality

Air quality is affected by emissions from all direct and support activities for natural gas and oil operations such as exploratory drilling, construction, development and production operations, and support craft activities. Table 4.2-2 summarizes the estimated emissions from all OCS direct and support activities in the Pacific Region for 1987 through 1991.

The MMS developed and uses the Offshore and Coastal Dispersion Model to determine the onshore impact of inert emissions released from offshore sources. The model accommodates the unique dispersion regime and source characteristics of overwater pollutant releases and their relation to shoreline and overland terrain dynamics. Based on an in-house MMS modeling analysis, the onshore impacts from individual facilities, and cumulatively from several facilities in a common area, were less than 1 $\mu g/m^3$ for the inert pollutants.

Air quality modeling is a tool used to demonstrate a cause-and-effect relationship between emissions and ambient air quality. Photochemical models are applied because ozone production in the ambient air is nonlinear, as are the emission relationships of the ozone precursors, reactive organic compounds, and NO_x. The models are computer programs that simulate the atmosphere and calculate ambient ozone concentrations using atmospheric dispersion and photochemical algorithms. These algorithms employ day-specific emission inventories and meteorology. Ozone is the major pollutant of concern for the onshore regions, which are designated as nonattainment areas for the Federal and State standards for ozone. A cooperative air quality study for the Santa Barbara Channel area, the Joint Interagency Modeling Study (JIMS), assessed the cumulative impacts of emissions from direct and indirect OCS activities on onshore ozone concentrations in Santa Barbara and Ventura Counties. The study was conducted in cooperation with the Santa Barbara and Ventura Air PollutionControl Districts (APCD's), the EPA, the California Air Resources Board, and the MMS. Three distinct meteorological scenarios entailing site-specific data were used to represent meteorological conditions that are highly conducive to ozone formation. For meteorological conditions similar to the three scenarios analyzed by JIMS, it was estimated that the maximum onshore concentrations from existing OCS operating facilities are less than 1 part per hundred million for ozone. By comparison, the NAAQS for ozone is 12 parts per hundred million. The JIMS estimation is based on the location and number of OCS operations in conjunction with onshore receptors.

The MMS modeling analysis placed the levels of the inert emissions associated with offshore sources at less than 1 $\mu g/m^3$. By comparison, the average annual NAAQS for NO_2 is 100 $\mu g/m^3$. A photochemical modeling analysis was performed for the JIMS study to assess the effect of OCS operations on air quality in the South Central Coast Air Basin in California. The results of the analysis showed concentrations well below the NAAQS.

Table 4.2-2. Estimated Emissions from OCS Direct and Support Activities in the Pacific Region, 1987 through 1991

Activity	Pollutant Emissions (tons)				
	NO_x	CO	SO_2	VOC[1]	TSP
Exploration Drilling	445	80	41	15	92
Construction:					
Pipeline[2]	75	19	9	2	8
Platform	884	198	86	25	71
Development/Production	5,464	1,442	953	5,939	219
Vessel Traffic[3]	3,450	458	186	298	215
Oil Spills	—	—	—	295	—

[1]Fugitive hydrocarbon emissions not included.
[2]Assumes 250 bbl of fuel/mi. Based on emission factors from table 3.4-1, Compilation of Air Pollution Emission Factors (EPA, 1985).
[3]Vessel NO_x emissions (Kearney, 1991); remaining vessel emissions are MMS estimates.

Effects of OCS Drilling/Construction/Production Activities: Exploratory drilling activities produce emissions primarily from the prime movers used in both power and propulsion equipment and from resultant flaring associated with well testing. A total of 12 exploratory wells was drilled between 1987 and 1989 in the Pacific Region, with no new exploration drilling in 1990 and 1991. It takes an average of 80-120 days to perform all of the exploratory operations necessary for determination of the prospect. Exploration drilling is considered a temporary activity, and it is unlikely that an activity of such limited duration would hinder the efforts of an area to attain or maintain ambient air quality standards.

Construction operations include emissions from platform installation, pipeline and power cable construction, and onshore support facilities. Approximately 29 line miles (46 km) of OCS pipelines were constructed in the Pacific Region between 1987 through 1991. Pipeline construction emissions were identified and mitigated by applying available control technologies for marine vessels including ignition timing retard, turbocharging, and other controls to reduce the amount of pollutants emitted.

Construction operations involving platform installations in the Pacific Region occurred in 1987 with the topside installation of Platform Gail, and in 1989 with the jacket installations of Platforms Harmony and Heritage. Construction emissions were mitigated through agreements between the facility operators and the APCD's in Ventura and Santa Barbara Counties. Mitigations involved controls on the marine vessels mentioned above and emission offset requirements specified by the APCD's.

One onshore construction project occurred in 1988 to support OCS operations at the SYU. Exxon constructed a separation, treatment, and gas processing plant at Las Flores Canyon in Santa Barbara County. The particulate emissions associated with land clearing and earth movement were mitigated, consistent with the California Environmental Quality Act and local laws and regulations.

Through 1991, there was a total of 24 OCS natural gas and oil facilities (20 producing platforms, 1 oil and gas processing platform, 2 nonproducing jackets, and 1 Offshore Storage and Treatment [OS&T] vessel) operating in the Pacific Region. Emission generating activities from production operations entail power production, flaring/venting, and various intermittent sources such as cranes, emergency generators, firewater pumps, and support vehicle operations. Power production demand may be divided into two parts, a relatively stable base-load and a load dependent on production levels of natural gas and oil. Of the 24 OCS facilities, 10 platforms and the OS&T are covered by agreements with onshore air pollution control agencies. These agreements involve several control technologies, including the use of low sulfur fuel, injection timing retard, water injection, waste heat recovery, and inspection and maintenance programs to minimize fugitive hydrocarbon emissions. These mitigations minimize air quality effects both locally at the platform and cumulatively in the Pacific Region, and emissions from these facilities are being monitored by the respective air pollution control agencies. The emissions associated with production activities are included in table 4.2-2.

Production operations in the Pacific OCS also include support activities that use crew and supply boats and helicopters to transport personnel and supplies to the offshore facilities. Typical operations include two crew boats per day, two supply boats per week, and three-five helicopter trips per week. Emissions from these support operations are quantified in table 4.2-2.

Conclusion: No significant cumulative effects on air quality from natural gas and oil drilling/construction/production operations in the Pacific Region have been identified from 1987 through 1991.

Effects of OCS Oil Spills: From 1987 through 1991, a total of 187 bbl of oil from 15 OCS-related spills were recorded in the Pacific Region. These spills resulted in no significant incremental or cumulative effects to air quality. Table 4.2-3 summarizes crude, diesel, and other petroleum spills occurring in the Pacific Region for 1987 through 1991. In addition, an estimated 365 bbl of oil seepage per year continues as a result of the 1969 Santa Barbara oil spill (USDOI, MMS, 1988a).

Once on the ocean surface, oil spreads into a thin layer due to the combined effects of wind and ocean currents. This direct exposure to the atmosphere results in the evaporation of the more volatile fractions of the crude, with weather and sea conditions playing major factors in the release rate. Emissions from these 15 oil spills measured an estimated 0.16 tons per day. By comparison, natural seeps in the Santa Barbara Channel are estimated to release 6 tons per day of reactive hydrocarbons into the atmosphere (Chambers Group, Inc., 1986). The resultant emissions from oil spills from OCS operations and continued seepage from the Santa Barbara spill are quantified in table 4.2-2.

Table 4.2-3. OCS Crude, Diesel, or Other Spills in the Pacific Region, 1987 through 1991

Year	Spill Size (bbl)	Fluid Spilled
1987	1.0	Crude Oil
	2.5	Crude Oil
	8.0	Crude Oil
1988	1.0	Condensate
	1.5	Condensate
1989	1.2	Crude Oil
	2.0	Crude Oil
	5.0	Hydraulic Oil
1990	1.0	Crude Oil
	100.0	Mineral Oil
1991	1.0	Crude Oil
	1.0	Crude Oil
	1.3	Crude Oil
	10.0	Crude Oil
	50.0	Crude Oil

Conclusion: No significant cumulative effects on air quality resulting from OCS oil spills in the Pacific Regions, 1987-1991, were identified.

4.2B Biological Environment

4.2B1 Lower Trophic Organisms

Effects of Offshore Discharge of OCS Muds and Cuttings: From 1987 through 1991, approximately 390,000 bbl of drilling muds and 200,000 bbl of cuttings were discharged in the Pacific Region as a result of drilling 119 exploratory and development wells. Nearly 90 percent of this activity and concomitant discharges of muds and cuttings occurred in the Santa Barbara Channel and Santa Maria Basin.

The lower trophic organisms of concern in the vicinity of Pacific Region muds and cuttings discharges are bottom-inhabiting invertebrates. Most of the bottom habitat in the Pacific Region consists of soft sediments where organisms live primarily within the sediment below the surface. Fewer organisms live on the bottom's surface. Since soft bottom communities remain essentially the same for miles at similar depths (Fauchald and Jones 1977), no significant cumulative effects on soft-bottom benthic communities, except immediately around platforms, were identified.

The other type of habitat in the Pacific Region is hard bottom. In this rare habitat, nearly all lower trophic organisms live on the surface and are more directly exposed to sedimentation. Thus, due to greater direct exposure and the scarcity of habitat, the rocky hard-bottom communities have a greater potential of being affected by muds and cuttings discharges.

Drilling muds and cuttings can affect lower trophic organisms through burial, clogging of respiratory or feeding structures, or toxicity. Particularly in the case of hard or rocky bottoms, settlement of appreciable amounts of drilling sediments could change the composition of the bottom surface and favor a different species composition more compatible to softer bottoms. According to Neff, Rabalais et al. (1985) sublethal effects on certain bottom organisms occur several orders of magnitude lower than lethal effects. However, the authors concluded that organisms in the water column, such as plankton, will never be exposed to drilling muds long enough to show even sublethal effects because the rate of mud dilution is so rapid. Effects in the immediate vicinity of the platform may occur because of the slight toxicity of drilling muds; a bioaccumulation of barium and chromium; and slight accumulations of copper, cadmium, and lead.

The area of sea bottom covered by drilling muds will vary significantly with depth and currents. The horizontal distance reached by drilling muds is greater than that of drill cuttings because of the muds' lighter weights. Studies by NRC (1983) and Battelle (1990) suggest that drilling fluids can be deposited several kilometers from the platform, but effects, if they occur, are at lesser horizontal distances. The MMS-funded CAMP sampling in the Santa Maria Basin (Battelle Ocean Sciences, 1991) reported possible discharge-related effects on hard bottoms within 400-500 m of drilling operations. However, Menzies et al. (1980) reported effects on benthic communities out to distance of 800 m from drilling muds on Georges Bank.

The biological stipulation, which has been in effect for all exploratory or development processes, effectively requires the lessee either to avoid sensitive hard substrate areas (hard-bottoms areas) by relocating the wells or platform site or to conduct a biological survey to determine the area's composition or sensitivity. One biological survey was conducted during exploratory drilling on POCS-0456, a tract associated with the Point Arguello Field. Since 1987, the original exploratory well drilling plans have been modified on at least three tracts to avoid hard bottoms.

Battelle Ocean Sciences (1991) conducted a monitoring study of the impacts caused by drilling discharges on hard-bottom communities in the Santa Maria Basin along a gradient of increasing distances from the production platform in the Pt. Arguello Field. The monitoring study is continuing with its objectives of separating natural background variation from potential low-level cumulative effects caused by drilling activities.

Battelle Ocean Sciences (1991) reported that the populations of hard-bottom species within 400-500 m of Platform Hidalgo in the Santa Maria Basin exhibited some changes that were possibly caused by the deposition of drilling muds and cuttings. Several variables such as water depth, relief of the rocky outcrop, and current direction were involved; however, conclusions about drilling fluids causing effects could not be definitive. The study is being continued to attempt to get a better line on the actual cause of the effects. The effects do not include the formation of a sediment mound, and mortality by burial is not involved. Boesch and Robilliard (1985), however, reported that the deposition of drill cuttings may, depending on water depth, create a mound that ranges up to a few meters high and covers an area 100-200 m in diameter. These mounds contain substantial quantities of biological materials (such as mussel shells) originally attached to the platforms legs, but with the death of the organism, these materials have fallen to the ocean floor. These mounds have altered the original communities—becoming richer communities in terms of biomass and productivity. However, since the habitat remains a sediment habitat, it is comprised of different numbers of many of the same species that were present prior to drilling. This altered community will last at least the life of the platforms (approximately 25 years).

The biological stipulation curbs most drilling on hard bottoms, and no platform in the Pacific Region is located directly on hard bottoms. Platform Hidalgo, however, is located near several hard-bottom outcrops. No mounds have formed on the hard bottoms, but there may be a slight change in the distribution of several of the species due to the discharge of drilling fluids. Although some effects to hard-bottom species occurred near Platform Hidalgo as the result of drill muds and cuttings, cumulative effects to hard-bottom communities were not significant. This fact will remain true as long as hard bottoms are avoided.

Conclusion: Although burial caused soft-bottom population deaths within 200 m of platforms and community alterations within 500 m of platforms, significant cumulative effects to the soft-bottom community did not occur. Also, because the biological stipulation requires OCS operators to avoid hard bottoms, significant effects to hard-bottom communities did not occur. Measured impacts to these communities, if they actually are caused by drilling muds and cuttings, are minor.

Effects of OCS Pipeline Construction: The effects associated with the installation of subsea oil and gas pipelines are the smothering and crushing of the subtidal and intertidal soft- and hard-bottom lower trophic organisms. These effects result from the positioning and setting of lay barge anchors and cables, and pipelaying. The total amount of disturbance to subtidal benthic communities would depend on the methods of pipeline and anchoring installation (URS Company, 1986; USDOI, MMS, 1987). Approximately 29 miles of OCS pipelines were constructed in the southern Santa Maria Basin and Santa Barbara Channel in the Pacific Region between 1987 through 1991.

The studies of Centaur Associates, Inc. (1984), ADL (1985), and Chambers Group, Inc. (1986) have determined that at certain soft-bottom areas in southern California the positioning of anchors can result in anchor scars (trenches and mounds) on the seafloor. The scars from natural gas and oil operations ranged from 50 to 540 m in length and could remain for 2-5 years in fine soft-bottom sediments. Such seafloor disturbances were not continuous from pipeline to anchor, but occurred at a horizontal distance of 3 to 7 times the depth of the anchor. Additionally, the anchor cables could disturb bottom areas for a length of approximately 490 m per anchor and could create a 0.6-m swath. The anchor scars serve as traps for fine sediment and organic material. The resulting microhabitat from this disturbance (sediment alteration) in the affected areas could be different from that of the surrounding environment. This difference could result in a temporary change in species composition since soft-bottom infauna are dependent upon grain size of the sediment.

Temporary and localized sediment scouring would result from the anchoring events. Theoretically, this scouring would reduce dissolved oxygen concentrations and interfere with the nourishment of suspension feeding benthic species, thus causing alteration of ecological relationships, displacement/reduction of some species, or enhancement of the population of others. These effects are presumed to cease after 1 or 2 years (USDOI, MMS 1992b). The installation of pipelines would cause a temporary 20-m (65 ft) wide disturbance along their axis. However, the pipeline itself generally causes less of an effect than anchor scars and consists of an insignificant interference with ecological impacts lasting for less than a year.

According to ADL (1985), Chambers Group, Inc (1986), URS Company (1986), and USDOI, MMS (1987), the installation of pipelines and associated anchoring activities would cause loss of attached hard-bottom organisms due to crushing and displacement of the biota and hard substrate in the 20-m (65-ft) corridor combined with a small portion under the positioning anchors. Hard substrates are rare, and they support diverse and long-lived communities. Hard-bottom communities would require longer than 5 years to recover from disturbances caused by pipeline construction activities. This delay is due to the slow recovery of the hard-bottom's biotic community. Because hard bottoms are rare and sensitive and require long recovery periods, they are avoided during pipelaying in the OCS whenever possible (e.g., the Pt. Arguello and SYU projects).

The biological stipulation, which effectively requires a developer either to avoid a particularly sensitive area (hard-bottoms areas) or to conduct a biological survey to determine the composition or sensitivity of the area, has been in effect for pipeline construction as well as exploratory or developmental processes. Although no biological survey has been conducted as a result of pipeline routes since 1987, pipeline construction operations have had to avoid placing anchors on hard bottoms. In fact, the Conditions of Approval for pipeline and power cable installation in the SYU specified that Exxon use offshore installation techniques to minimize turbidity, and that they use dynamically positioned vessels to lay all pipelines and power cables from platforms to shore. This use involved about 22 anchor settings and retrievals in Federal waters. These actions resulted in a reduction of 200-300 anchoring events compared to operations involving standard lay barges; consequently, there was a proportional decrease in the levels of turbidity from resuspended sediments (USDOI, MMS, 1991b). Pipelaying activities were monitored by MMS inspectors throughout the construction period. As another measure of safety, pipelines in the Pacific Region have not been buried to reduce the danger of rupture during earthquakes.

Conclusion: Although soft-bottom populations experienced a temporary (less than a year) change in species composition caused by anchor scars or anchor disturbances, significant cumulative effects to the soft-bottom community did not occur from pipeline construction from 1987 through 1991. Because the biological stipulation requires OCS operators to avoid hard bottoms, pipelines were not placed on these habitats.

Effects of Offshore Discharge of OCS-Produced Formation Waters: From 1987 through 1991, an estimated 210,000 bbl of produced formation waters were discharged from OCS activities in the Pacific Region. Produced water is discharged offshore only into the Santa Barbara Channel. However, produced water from platforms in the Santa Maria Basis is shipped to shore and disposed of in onshore wells, while that from platforms off Long Beach is disposed of in down-waterflood and disposal wells. The lower trophic organisms affected by produced formation water are the temporary drifting planktonic species. Since OCS-produced water is discharged only into the Santa Barbara Channel, effects to lower-trophic-level plankton occurred only there.

In 1989, in conjunction with the MMS-funded Southern California Educational Initiative, scientists at the University of California, Santa Barbara, began field and laboratory studies on the effects of produced formation waters on the reproductive lifestages of several species of marine invertebrates. The field work focused on an outfall located at a depth of 10-12 m in the Santa Barbara Channel near Carpinteria. The studies are ongoing, but preliminary results have been obtained. Although these studies have not demonstrated acute toxicity to marine organisms from produced water (Krause et al., 1992), sublethal effects have been observed in sea urchin embryos in the laboratory (Baldwin et al., 1992) and in adult mussels (Osenberg et al., 1992) outplanted at distances of up to 100 m from the source (Cherr et al., 1992).

The studies begun under the Southern California Educational Initiative indicate that planktonic larvae can be affected by produced water plumes, even from discharges in open-coast environments such as that found at the Carpinteria outfall (Raimondi and Schmitt, 1992). However, it is impossible at this stage to determine whether the discharge of produced water results in effects on marine organisms at the population level.

Recent field studies by Raimondi and Schmitt (in press) have shown that abalone larvae held in containers within 100 m of produced water diffusers for 4 continuous days showed as much as a 30-percent reduction in survival. Also, settlement of the larvae onto hard, benthic substrates was also delayed. Although the 4-day exposure period used in the test is not truly representative of the short exposure periods planktonic larvae are expected to encounter on the OCS, exposure for far shorter periods and distances less than 100 m from the diffuser resulted in several effects to the larvae. The larvae temporarily stop swimming, slowly sink, and then return to normal behavior slowly only after exposure has ceased. Effects such as these may cause reduced survival rates in the marine environment. As the authors suggest, this question seems worthy of further study. The evidence does not suggest, however, that the effects on the population are significant enough to alter population levels, with the possible exception of individuals that may settle on or within a small distance from a platform. This latter supposition has not been documented.

Conclusion: From 1987 through 1991, some settling by temporary drifting plankton larvae was hindered by the discharge of OCS-produced formation waters from the exploration and production wells drilled in the Santa Barbara Channel. However, alteration of the population levels was not documented.

Effects of OCS Oil Spills: From 1987 through 1991, 15 small (> 1 bbl) accidental OCS-related oil spills (totalling 187 bbl) from platforms or pipelines occurred on the Pacific OCS. Lower trophic organisms affected by oil spills are those inhabiting estuaries and intertidal habitats. None of the OCS-associated spilled oil reached shore.

Subtidal benthic organisms can be affected by contact with an oil spill, especially in shallow areas. However, they are less susceptible to impacts for two reasons: (1) They are not subject to prolonged direct contact with oil as are intertidal organisms, which can be completely covered with oil when exposed during an entire low tide period. On flat surfaces, there are no currents, waves, or dissolution to remove oil from intertidal organisms during low tide. (2) The water motion of waves and currents is also involved. Subtidal benthic organisms are subject to currents, and shallow-water subtidal benthic organisms are subject to the energy of both waves and currents. Oil in high-energy environments with a lot of forceful water movement, such as occurs on the Pacific coast, breaks up or moves too rapidly or forcibly to remain in contact with benthic organisms very long, particularly when compared with oil in an estuary.

In the intertidal habitat, oil can remain in contact with lower trophic organisms for relatively long periods (lasting for several hours), when the water has receded at low tide and when the organisms are exposed directly to the oil and can become oiled again during the next tide. Communities on large, flat, or gently sloping rocky intertidal habitats have the greatest potential for impacts from oil spills on the ocean coast. Another factor that causes greater impacts is calm water without appreciable waves or currents, often referred to as low-energy environments. The habitat that most exemplifies calm water is the estuary.

Estuaries are shallow and have very little wave action. Oil under these conditions does not break up and disperse. It can remain in contact with a lower-trophic-level organism for relatively long periods and can settle to the bottom and penetrate into bottom sediments where it can become particularly harmful to plants and animals. Since estuaries in southern California are rare, closed part of the year, or with narrow openings, it is unlikely that the spill would enter an estuary.

The studies of ADL (1985), Bechtel Petroleum, Inc. (1985), Chambers Group, Inc. (1986) and USDOI, MMS (1983 and 1990b) suggest that the severity of impact by oil spills on rocky intertidal communities varies depending on sea state, residence time of the oil prior to contact, and isolation and configuration of the site contacted. Generally, isolated and flat rocky intertidal areas are more severely affected. Due to gravity, oil remains longer on flat surfaces than on sloped surfaces, thus resulting in smothering and toxic impacts to biological communities.

Help in oil-spill cleanup is available from response vessels stationed in San Luis Obispo Bay, the Point Conception area, and Santa Barbara by the Clean Seas oil-spill cooperative, and in the Los Angeles/Long Beach Harbor by the Clean Coastal Waters cooperative. Also, each offshore facility in the Pacific Region is required to maintain on-site oil-spill cleanup equipment capable of cleaning up small spills quickly. Periodic drills monitored by the MMS test the readiness of personnel and equipment to respond to a spill at a facility. These readiness requirements are primarily designed to ensure, to the fullest extent possible, that an oil spill would be contained or diverted from areas containing rich and sensitive lower-trophic-level organisms. The oil-spill response requirement is intended to prevent an oil spill from reaching the shoreline or estuaries and wetlands by maintaining state-of-the-art oil-spill containment and cleanup equipment and capabilities on site and in the vicinity of the drilling operations. This measure helps ensure that the actual physical equipment necessary for an adequate oil-spill response capability exists and is in a state of readiness and that oil-spill personnel are properly trained.

Conclusion: Because none of the oil spilled during 1987 through 1991 from OCS-related accidents reached shore, no impacts to shoreline, estuarine, or bottom lower-trophic-level organisms occurred in the Pacific Region.

4.2B2 Fish Resources

Effects of OCS Geophysical Surveying: Geophysical survey activities in the Pacific Region have been limited: 44 geophysical seismic survey permits were issued. Acoustic signals from air gun or water gun arrays used during deep seismic surveys can have lethal or sublethal behavioral effects on various life stages of fishery resources. These effects can be translated into effects on the fish populations as a whole and, consequently, on the fishermen who harvest those resources.

Because of the short duration of air gun sounds, Battelle Marine Research Laboratory and BBN Laboratories (Battelle and BBN) (1987) concluded that the effective detection thresholds of 110-130 decibels (dB) re μPa for air gun sounds are probably not masked by background noise. Battelle and BBN (1987) estimated that rockfish (*Sebastes* sp.) could hear survey sounds at a distance of 34 nautical miles (63 km) from a 250-dB source level for an air gun array and a 25Log(R) transmission loss.

Fish or invertebrate eggs and larvae may be damaged or killed if exposed to intense acoustic energy at close range. Northern anchovy yolk-sac larvae (2-4 days old) suffered significantly reduced survival and growth rates when exposed to sound pressures three to four times the levels that would occur normally if a full seismic array passed directly over the larvae at a distance of 3 m; however, eggs and larvae (15-22 days old) were not significantly affected (Holliday et al., 1987). Pearson et al. (1988) reported that peak sound pressures as high as 231 dB re μPa did not significantly affect Dungeness crab early larvae (zoea) survival, developmental rates, or behavioral responses. Pressure levels emanating from air guns may damage the swim bladders of juvenile and adult fishes at a fairly close range. No significant mortality occurred at a distance of 6 m, although juvenile cod were disoriented for up to 2 days. Damage to swim bladders of adult northern anchovy occurred at about 0.6-1.5 m at sound pressure levels of 233 dB (Holliday et al., 1987).

Fish hear and respond to single air gun or air gun array sources if they are exposed to moderately high sound pressure levels for at least several minutes. Pelagic schooling fish, such as herring and whiting, reacted to air gun-generated sound pressure levels of 180-188 dB re μPa by swimming away, either to deeper water or to another area (Dalen and Knutsen, 1986; Dalen, 1973 [as cited in Battelle and BBN, 1987]; Chapman and Hawkins, 1969).

Battelle and BBN (1987) observed that several species of rockfish gave alarm and startle responses to sounds from a single air gun. Startle responses (reflexive flexions, shuddering, rapid swimming) were not observed in caged rockfish below 200 dB re μPa. The threshold for alarm responses (changes in schooling behavior, vertical distribution, and activity level) was about 180 dB re μPa. Some subtle changes in behavior became evident at 161 dB re μPa. The fish appeared to return to their previous behavior within minutes after the air gun noise ceased. However, under conditions of the experiment, the fish may have become habituated to the noise.

The limited scientific evidence available suggests that significant effects on pelagic fish eggs and larvae would probably only occur relatively close to an operating air gun array. It seems unlikely that individual eggs and larvae would normally be exposed to more than one to two shots within the near-field influence of an air gun array during an actual seismic survey because of the following:

- the spacing and pattern of shot lines during actual geophysical surveys
- the extensive spawning areas of most species compared with the survey tracklines
- the high reproductive rates characteristic of species with pelagic eggs and larvae
- the patchy distribution of pelagic eggs and larvae
- the passive movement of eggs and larvae due to ocean currents and other transport processes
- the diel periodicity and vertical migrations characteristic of the larvae of many species

The probability is extremely low that populations or year classes of adult fish would be significantly affected by mortalities of pelagic eggs, larvae, or juveniles killed during seismic surveys. Behavioral effects are difficult to quantify, difficult to interpret relative to specific impacts, and difficult to assess at the population level. However, according to the few studies conducted thus far, the major effect of seismic surveys appears to be on the behavior of juvenile and adult fish, not on their survival. Behavior tends to return to normal shortly after the noise ceases, although habituation to sustained noise may occur.

Conclusion: No significant cumulative effects of seismic surveys on fish resources were documented for the Pacific Region from 1987 through 1991.

Effects of Offshore Discharge of OCS Muds and Cuttings: From 1987 through 1991, approximately 390,000 bbl of drilling muds and 200,000 bbl of cuttings were discharged in the Pacific Region as a result of drilling 119 exploratory and development wells. Nearly 90 percent of the drilling activity and, in turn, the discharge of drilling muds and cuttings occurred in the Santa Barbara Channel and Santa Maria Basin.

After studying the extensive research done on the effects of drilling muds and cuttings, the NRC (1983) concluded that "the effects of individual discharges are quite limited in extent and are confined mainly to the benthic environment." Neff (1987) concluded that "water column organisms will never be exposed to drilling fluids long enough and at sufficiently high concentrations to elicit any acute or sublethal responses."

Battelle Ocean Sciences (1991) found that variations in benthic epifauna did not seem to be related to the chemical toxicity of drilling mud constituents, and suggested that elevated concentrations of barium in suspended particles were unlikely to cause any toxic effects in hard-bottom epifauna. In a conclusion based on the results of many studies, Battelle Ocean Sciences (1991) found that "adverse biological effects on the benthos, when observed, have been limited to within about 1 km of the discharge source . . . . Results of the present study suggest that any biological effects due to the drilling muds were related to physical effects of the increased particle loading."

Drilling muds are from practically nontoxic to slightly toxic to fish (Neff, 1987). Increased bottom topographic relief caused by accumulations of cuttings, fallout of mussels and other fouling organisms from submerged platform structures, and the structures themselves tend to create an artificial reef effect that attracts fish and motile invertebrates to the area for feeding.

Potential impacts to target species are mitigated, to the maximum extent practical, by discharge requirements imposed by the EPA through the issuance of NPDES permits. Under these permits, the volume, frequency, and contents of all discharges are regulated to protect fish and other marine life from adverse effects.

Biological effects of drilling muds are probably related to the physical effects of increased sedimentation, not to the toxic effects of chemicals in the muds. The magnitude of impact of drilling muds and cuttings on benthic organisms is related to the amounts discharged and to the environmental conditions. More material accumulates in low-energy environments, thereby enhancing artificial reef effects. Discharged muds and cuttings will bury food organisms in the area and render them unavailable to bottom-feeding fish, resulting in temporary displacement of these fish, until drilling stops and resettlement occurs.

Very little is known about the effects of drilling muds on pelagic fish. Drilling discharges might cause brief temporary changes in their distribution near the discharge point if they avoid the discharge plume. However, plume avoidance would not cause any discernible long-term impacts on the normal distribution, behavior, and catchability of pelagic fish.

Conclusion: Because direct and indirect effects on fish resources and their food supplies are localized, no significant cumulative effects from discharges of drilling muds and cuttings on fish resources were documented for the Pacific Region from 1987 through 1991.

Effects of Offshore Discharge of OCS-Produced Formation Waters: An estimated 210,000 bbl of produced formation waters were discharged from OCS activities in the Pacific Region from 1987 through 1991.

The discharge of formation waters introduces low levels of sulfur, hydrocarbons, and heavy metals into the marine environment. Gallaway (1981) concluded that produced waters are only slightly toxic and directly affect only the area within a few meters of the discharge point. Long-term effects, including the implications of the effects of heavy metals, remain to be assessed.

Studies addressing the long-term localized or areawide impacts from formation water discharges were not undertaken or completed in the Pacific Region during 1987-1991. Potential effects on target species are mitigated, to the maximum extent practical, by discharge requirements imposed by EPA through the issuance of NPDES permits. Under these permits, the volume, frequency, and contents of all discharges are regulated to protect fish and other marine life from adverse effects.

Given the rapid dilution of discharged produced water in offshore waters and given the similarity in composition of produced water and normal marine water, the effects of produced water on fish resources are expected to be limited. Additional information on this topic will become available once MMS-funded studies undertaken by the University of California at Davis and Santa Barbara are completed.

Conclusion: During this report period, no significant cumulative effects of produced water on fish resources were documented for the Pacific Region.

Effects of OCS Oil Spills: Although no substantive impacts from OCS-related oil spills have been observed for more than 20 years (USDOI, MMS, 1991b), environmental degradation that might result from such spills continues to be one of the greatest causes of concern about OCS development.

During the period 1987-1991, 15 small (>1 bbl) OCS-related spills occurred in the Pacific Region. These spills, all of which occurred at platforms or pipelines, averaged 37 bbl per year. Seepage of oil from the 1969 Santa Barbara spill continues at the rate of about 365 bbl per year (USDOI, MMS, 1988a). For comparison, natural seeps in the Santa Barbara Channel are estimated to introduce 40-670 bbl of oil into the marine environment each day (USDOI, MMS, 1988a).

An oil spill that contacts fish or shellfish can kill or harm individuals or affect entire populations. Sublethal effects include inhibition of feeding, growth, development, energetics, and reproduction. The nature and severity of the biological effects of oil exposure depend on the kind of oil involved, the extent to which the oil has weathered, and the sensitivity of the lifestage (e.g., egg, larva, juvenile, adult) of the organism involved. These effects are modified by the ability of an organism to accumulate and metabolize hydrocarbons. Metabolism of these compounds affects their transformation into more or less toxic derivatives and affects their deposition within or elimination from an organism.

Fishes with more limited distributions within southern California that are vulnerable to oil-spill effects include bay and estuarine fishes. Pacific herring would be most vulnerable to oil spills during spawning (primarily December-February) within bays and estuaries. A large oil spill contacting these areas during spawning could contaminate spawning substrate; affect availability of food supplies; and cause egg, larval, or adult mortalities either directly or indirectly. While sublethal/lethal effects on individual Pacific herring could occur in locally affected areas, the magnitude of resulting mortality is likely to be too small to be measurable as a decline in overall population size since the majority of the California population is located outside the area. Replacement of reduced local stocks is expected to be rapid (less than 2 years), as areas are recolonized from abundant and mobile stocks, which mature rapidly, spawn several times during their lives, and are prolific breeders.

The sensitivity of early developmental stages, the observed impairment of reproductive processes, and the potential long-term effects on populations suggest that chronic exposure to oil may alter the dynamics of benthic populations, including those of demersal fish (Capuzzo, 1987). However, the NRC (1985) concluded that "a direct impact [of oil spills] on fishery stocks has not been observed."

Conclusion: No significant cumulative effects of OCS oil spills on fish resources were documented in the Pacific Region during the report period.

4.2B3 Endangered or Threatened Species

The various endangered or threatened species in the Pacific Region include whales, sea otters, and birds. These are discussed below.

(a) Endangered Whales

Effects of OCS Seismic Surveying: During OCS exploratory operations, deep seismic surveys are made to investigate geological formations before drilling to help locate natural gas and oil reserves. The surveys are conducted by reflecting acoustic energy off subsurface layers and recording the reflections. The high-energy acoustical pulses used in seismic surveys are generated by air guns or water guns. From 1987 through 1991, 44 seismic surveys were conducted in the Pacific Region off northern California, in the Santa Barbara Channel, and off San Diego. Seismic surveys in these areas were conducted 5-95 km offshore and averaged 640 km of trackline (with a range of 30-3,700 km).

If the acoustic waves generated during seismic surveys exceed the ambient "background" noise, they can produce sublethal effects in endangered whales by interfering with communication or altering behavior. In controlled experiments, gray whales have exhibited startle responses, avoidance reactions, and other behavioral changes when exposed to seismic pulses at levels above 160 dB, which corresponds to a distance of about 3.6 km from an air-gun array (Malme et al., 1989). Less consistent reactions have occurred at received volume levels of 140-160 dB (Malme et al., 1983; 1984; 1989). However, Malme et al. (1989) concluded that baleen whales seem to be quite tolerant of noise impulses produced by marine seismic exploration.

Endangered Species Act biological opinions issued by the NMFS for 1987-1991 OCS activities concluded that geophysical seismic activities may create a stressful situation but are not likely to present a barrier to whale migration. Indeed, extensive geophysical exploration has been conducted off the California coast for more than 35 years. Over this period, the gray whale has recovered to population levels at or above precommercial whaling levels (Reilly, 1984) and is proposed for removal from the List of Endangered and Threatened Wildlife. Humpback and blue whales have also been sighted in increasing numbers in southern California waters in recent years.

Conclusion: Given the findings discussed above and the limited number of seismic surveys conducted in the Pacific Region during 1987 through 1991, seismic operations had no significant effect on endangered whale populations.

Effects of OCS Support Vessel Traffic: Noise and disturbance from OCS support vessel and helicopter traffic may be sources of impacts to endangered whales. Support vessels for activities in the Santa Barbara Channel and Santa Maria Basin operate out of bases in the Santa Barbara Channel; support vessels traveling to and from the four platforms in the Beta Unit operate out of Long Beach. Support vessels average 16 trips per week per platform, helicopters 3 to 5 trips per week per platform.

Noise from helicopter and service-vessel traffic may elicit a startle reaction from endangered whales or mask their sound reception. The reactions of gray whales to aircraft and/or certain aircraft noises have been examined systematically (Malme et al., 1989). Although sensitivity varies with whale activity, reactions including hasty dives, turns, and other altered behaviors have been observed (Ljungblad et al., 1983; Ljungblad et al., 1987; Malme et al., 1983; 1984). There is no evidence that single or occasional aircraft overflights cause long-term displacement (Malme et al., 1989).

Service vessels comprise the greatest amount of marine traffic associated with OCS activities. Although gray whales seem to ignore most low-amplitude vessel sounds, avoidance and approach responses have been observed in field studies (Watkins, 1986; Malme et al., 1989; Richardson et al., 1991). There is little information on the sound levels involved. Migrating gray whales have been observed to avoid the approach of vessels to within 200-300 m (Wyrick, 1954), summering grays to within 350-550 m (Bogoslovskaya et al., 1981).

Wolman and Rice (1979) hypothesized that increased vessel traffic off southern California might be causing greater numbers of whales to migrate farther offshore. The estimated percentage of gray whales using offshore routes through the Southern California Bight has increased over the years (Rice, 1965; Dohl, Norris et al., 1981; Dohl, Guess et al., 1983; MBC Applied Environmental Services, 1989a), but it is possible that earlier investigators may have simply overlooked the importance of offshore routes. As noted in the section on seismic surveying, the gray whale population has grown steadily in recent decades, and humpback and blue whales are appearing in increasing numbers. There is no evidence that increased vessel traffic has resulted in adverse impacts on any endangered cetaceans, including migrating gray whales.

In December 1991, in conjunction with the installation of offshore pipelines and power cables for the SYU expansion project in the western Santa Barbara Channel, Exxon was required to implement a marine mammal monitoring program (Exxon, 1991; Woodhouse and Howorth, 1992). The monitoring program was designed to lessen possible impacts by reducing physical contact between construction vessels and equipment and marine mammals that begin migrating southward through the Santa Barbara Channel in December, particularly gray whales. Using a dedicated vessel, the region was monitored for 86 days. The monitoring vessel observed and tracked migrating gray whales through the construction area and alerted crew boats and construction vessels to the presence of whales. Relatively few gray whales were sighted in the construction area, but the lack of comprehensive baseline data on gray whale use of the area made it impossible to determine whether migratory pathways were being altered (Woodhouse and Howorth, 1992). Although two major pathways were identified, there was no evidence that the construction activities interfered with the gray whale migration.

Under the authority of the Marine Mammal Protection Act, the NMFS proposed regulations to provide greater protection to whales, dolphins, and porpoises by not allowing people, vessels, and aircraft to approach them closer than a specified distance (57 FR 34101, August 3, 1992). The proposed rule sets a minimum vessel approach distance of 100 yards (91.4 m) for whales. It also prohibits aircraft from operating within 1,000 feet (304.8 m) of cetaceans. Research involving any closer approach to animals would require a research permit.

Through an Information to Lessees (ITL), lessees in the Pacific Region are provided with guidelines for protecting marine mammals and birds from aircraft. This ITL states that

> Aircraft should operate to reduce effects of aircraft disturbances on seabird colonies and marine mammals, including migrating gray whales, consistent with aircraft safety, at distances from the coastline and at altitudes for specific areas identified by the U.S. Fish and Wildlife Service (FWS), National Marine Fisheries Service (NMFS), and the California Department of Fish and Game (CDFG). A minimum altitude of 1,000 feet is recommended near the Channel Islands National Marine Sanctuary to minimize potential disturbances. The CDFG and FWS recommend minimum altitude restrictions over many of the rookeries and colonies.

Based on experiences in southern California, the belief is that accidental collisions between endangered whales and support-base traffic are unlikely events. Although large cetaceans were occasionally struck by freighters or tankers and sometimes by small recreational boats, no such incidents were reported with crew or supply boats off California (I. Lagomarsino, NMFS, pers. comm.) during 1987 through 1991.

Conclusion: During the report period, there was no evidence that OCS-related support vessel traffic in the Pacific Region from 1987 through 1991 adversely affected any endangered cetacean, including migrating gray whales.

Effects of OCS Oil Spills: During the period from 1987 through 1991, 15 OCS-related oil spills (>1 bbl) occurred in the Pacific Region, spilling a total 187 barrels of oil. The spilled oil contacted a very small percentage of habitat available to endangered whales and other endangered cetaceans.

Several recent studies (reviewed by Geraci and St. Aubin, 1985b and 1990) attempted to determine the possible effects of oil on marine mammals. These studies focused on a marine mammal's ability to detect and avoid oil, behavioral effects, thermal effects, tissue damage due to oil contact, inhalation of oil, and ingestion of oil including toxicity and bioaccumulation.

A field study of the reactions of migrating gray whales to naturally occurring oil slicks in the Santa Barbara Channel (Evans, 1982) recorded mainly subtle and short-term responses to the presence of oil, such as changes in direction. When the 1969 Santa Barbara oil spill occurred, gray whales were beginning to arrive in the Santa Barbara Channel on their northward migration, passing through or west of the slick (Brownell, 1971); at least one group of gray whales was sighted moving northward through the slick, blowing as they swam (Easton, 1972; Geraci, 1990).

Geraci and St. Aubin (1982, 1985b) conducted experiments to test the effect of petroleum hydrocarbons on cetacean skin and found that cetacean epidermis is nearly impenetrable to even the highly volatile components in oil. They concluded that realistic contact with oil would be less harmful than had previously been proposed (Geraci and St. Aubin, 1980; Albert, 1981).

However, the toxic, volatile fractions in fresh crude oils could irritate and damage cetacean soft tissues, such as the mucous membranes of the eyes and airways, with effects as severe as death in extreme cases (Geraci, 1990). A whale or dolphin unable or choosing not to leave the area during the first few hours after a spill, when vapor concentrations are still high, would inhale vapors and might be harmed. The extent of injury would depend on the health of the animal, the state of its lungs, and its response to stress (Thomson and Geraci, 1986). Although sudden mortality could result if rapid breathing were compounded by a sudden release of adrenalin, it is most likely that the animals would experience some irritation of respiratory membranes and absorb hydrocarbons into the blood stream (Geraci, 1990).

It is also possible that oil residues might adhere to baleen plates, block the flow of water, and interfere with feeding. Geraci and St. Aubin (1982; 1985b) studied the fouling effects of oil on the baleen of several species, including gray whales. They concluded that a spill of heavy oil or residual patches of weathered oil could foul plates enough to interfere with feeding efficiency for several days, and that such effects would probably be cumulative in heavily fouled areas such as the center of a spill or a contaminated bay.

It was suggested that cetaceans could consume damaging quantities of oil while feeding, but Geraci (1990) believes it is unlikely that a whale or dolphin would ingest much floating oil. Because of their feeding habits, however, gray whales could possibly consume floating tar balls (Calkins, 1979) or contaminated bottom sediments (Hansen, 1992).

Baleen whales—such as blue, fin, or humpback whales—in the vicinity of a spill could ingest oil-contaminated food (especially zooplankton, which actively consume oil particles) (Geraci, 1990). Feeding gray whales might ingest oil-contaminated benthic amphipods, since many benthic invertebrates can accumulate toxic residues from bottom sediments (Gilfillan and Vandermeulen, 1978). Thus, these whales could ingest petroleum long after a spill had dissipated.

On the basis of gray whales' restricted foraging habitat and benthic feeding strategy, Würsig (1990) rates them as the baleen whale most vulnerable to the effects of oil. However, most of this risk is assumed to occur at the species' Alaskan feeding grounds. On the other hand, migrating gray whales, which do little feeding (Nerini, 1984; Oliver et al., 1984), are apparently much less vulnerable to the effects of spilled oil.

The only OCS-related oil spill in the Pacific Region to contact endangered cetaceans resulted from a blowout on Union Oil's Platform A in the eastern Santa Barbara Channel in January 1969. When the Santa Barbara Channel oil spill began, gray whales were beginning to arrive in the Channel on their northward migration. By April, as much as 70,000 bbl of oil was spilled, and as much as 2,000 km^2 of water surface were contaminated (Geraci, 1990). Gray whales moved northward through the slick during this period. Although six dead gray whales were recovered in the area between January and the end of March, no link was established between oil contamination and mortality. In fact, one report (Battelle Memorial Institute, 1969) concluded that the whales avoided the oil or were unaffected by contact with it. In other words, no effects on the gray whale population or migration were observed.

Conclusion: The OCS-related oil spills in the Pacific Region from 1987 through 1991 were all small (less than 187 bbl total) and contacted a very small percentage of the habitat available to endangered cetaceans. No adverse impacts on endangered cetaceans from accidental oil spills in the Pacific Region were observed.

(b) Sea Otters

Effects of OCS Seismic Surveying: From 1987 through 1991, 44 seismic surveys were conducted in the Pacific Region off northern California, in the Santa Barbara Channel, and off San Diego. These surveys were conducted 5-95 km offshore and averaged 640 km of trackline (with a range of 30-3,700 km). No OCS seismic surveys were conducted off the sea otter's mainland range from 1987 through 1991.

Sea otters in California reside in waters less than 18 m deep and rarely move more than 2 km offshore (Riedman, 1987). Generally, seismic surveys in the Pacific Region are conducted a minimum of 5 km from shore. Part of the seismic noise studies conducted by Malme et al. (1983, 1984) and Riedman (1983, 1984) monitored the behavior of sea otters exposed to seismic pulses along the California coast. The sea otters did not display any overt reactions at distances as close as 0.9 km from the air gun array, suggesting that sea otters are less responsive to noise pulses from marine seismic exploration than are certain baleen whales (Richardson et al., 1991).

Conclusion: Because no seismic surveys were conducted offshore the sea otters' mainland range during 1987 through 1991, no impacts from these activities occurred in the Pacific Region.

Effects of OCS Support Vessel Traffic: Support vessels for activities in the Santa Barbara Channel and Santa Maria Basin operate out of bases in the Santa Barbara Channel; those traveling to and from the four platforms in the Beta Unit operate out of Long Beach. Support vessels average 16 trips per week per platform, helicopters 3 to 5 trips per week per platform.

No systematic studies have been made of the reaction of sea otters to aircraft and helicopters (Richardson et al., 1991). During aerial surveys of the California sea otter range conducted at an altitude of about 90 m (Bonnell et al., 1983), the otters did not react to the two-engine survey aircraft.

Although sea otters will often allow close approaches by boats, they will sometimes avoid heavily disturbed areas (Richardson et al, 1991). Garshelis and Garshelis (1984) reported that sea otters in southern Alaska tend to avoid areas with frequent boat traffic, but will reoccupy those areas in seasons with less traffic.

Conclusion: Because of the following reasons, no effects on sea otters from OCS support vessel traffic in the Pacific Region, 1987 through 1991, were detected: (1) OCS helicopter traffic operated out of Santa Maria, Lompoc, and airports in the Santa Barbara Channel and was routed south of the main sea otter range; (2) Supply and crew vessel traffic associated with the Pacific OCS was based at ports in the Santa Barbara Channel, and vessel traffic in the Santa Maria Basin passed well offshore of the sea otter range.

Effects of OCS Oil Spills: From 1987 through 1991, 15 OCS oil spills (>1 bbl) occurred in the Pacific Region, spilling a total 187 bbl of oil. These OCS-related spills were all associated with platform operations and pipelines well offshore of the sea otter habitat.

Sea otters are among the marine mammals most sensitive to the effects of oil contamination because they rely almost entirely on maintaining a layer of warm, dry air in their dense underfur as insulation against the cold (Kooyman et al., 1977; Geraci and St. Aubin, 1980; Geraci and Williams, 1990). Even a partial fouling of an otter's fur, equivalent to about 30 percent of the total body surface, can result in death (Kooyman and Costa, 1979). This was clearly demonstrated by the non-OCS 1989 *Exxon Valdez* oil spill in Alaska (Davis, 1990). Earlier experimental studies had indicated that sea otters would not avoid oil (Barabash-Nikiforov, 1947; Kenyon, 1969; Williams, 1978; Siniff et al., 1982), and many otters were fouled by oil during this Alaskan spill.

Greater protection of sea otters from the effects of oil spills resulted from California Senate Bill 2040 in 1990, which provides for the construction of a permanent facility to clean and rehabilitate oiled sea otters. A statewide program to address the needs of all oiled wildlife is also being developed. The sea otter facility, which will be located at the University of California's Long Marine Laboratory on Monterey Bay, is scheduled to be operational in 1994. Prior to completion of the permanent cleaning and rehabilitation center, five interim facilities located on the central and southern California coasts will be equipped and maintained.

Conclusion: Because OCS-related spills occurring between 1987 through 1991 were all associated with platform operations and pipelines that were well offshore of the sea otter habitat, no documented effects on sea otters from spilled oil occurred in the Pacific Region.

(c) Endangered Birds

Endangered birds in the Southern California OCS Planning Area during the report period included the California brown pelican and least tern.

Effects of OCS Support Vessel Traffic: Vessel and helicopter traffic associated with OCS activities in the Pacific Region can cause disturbances to endangered birds, such as the California brown pelican and the California least tern, especially during the nesting season. Each platform in the Pacific Region may be visited by as many as 16 crew and supply vessels per week. Vessel traffic originates from the ports of Long Beach and Port Hueneme, and other ports along the Santa Barbara Channel. Three to five helicopter flights to each platform may occur weekly depending on the status and type of activity. Helicopter flights originate out of airports in Long Beach, Oxnard, and Santa Maria, California, depending on the location of the platform being serviced.

Low-flying aircraft, especially helicopters, can startle birds, causing short-term disruptions in normal behavior. Generally, this startle response lasts for only a few minutes after which birds return to their normal behavior with no lasting effect. However, during the breeding season, low-flying helicopter traffic may cause birds to abandon their nests temporarily. This abandonment can result in reduced productivity by exposing eggs and young to extreme temperatures, predation, and injuries. This startle response is tempered, to a large degree, by the well-known ability of birds to habituate to regularly occurring, chronic noises (Krebs, 1980; Johnson et al., 1985; Stephen, 1961; Langowski, 1969; Sharp, 1987). The time required and degree of habituation vary with the species, previous experience, frequency and nature of the disturbance, and time of year. There is some speculation that repeated disturbances will cause birds to abandon a favored roost, but this has not been documented. However, during 1987-1991, the populations of both the brown pelican and the least tern in California increased dramatically (D. Anderson, pers. comm. Oct. 1, 1993; Massey 1993).

The MMS provides OCS lessees with guidelines for protecting birds and marine mammals from aircraft through an ITL, which is discussed in section 4.2B3 on endangered whales.

To date, no studies have been conducted on the effects of OCS-related air and support vessel traffic on birds in southern California. However, air and vessel traffic almost constantly occur along the coast of southern California, and most bird populations have strongly acclimated to these sources of disturbance. In the United States, California brown pelican colonies occur on the Channel Islands, and air traffic over the islands is restricted to altitudes greater than 1,000 feet. The FWS and CDFG consider this altitude buffer sufficient to minimize potential disturbances to bird colonies. Air traffic over the coastline, where California least terns breed from May through August, is also restricted by Federal Aviation Administration (FAA) regulations to altitudes greater than 1,000 feet.

Conclusion: There is no evidence that OCS-related air and support vessel traffic affected endangered bird species in the Pacific Region during the report period. In fact, the populations of both brown pelicans and least terns in California increased dramatically from 1987 to 1991.

Effects of OCS Oil Spills: From 1987 through 1991, there were 15 small OCS-related oil spills in the Pacific Region. These spills were all very small in size, ranging from 1 to 100 barrels.

A detrimental impact to endangered birds, including the California brown pelican and California least tern, would occur if contact is made with oil. Hunt (1985) and Nero and Associates (1983), state that direct contact with oil results in the following:

- matting of plumage, reducing flying and swimming abilities
- loss of buoyancy, causing exhaustion and resulting in drowning
- loss of insulation, resulting in loss of body heat
- ingestion or accumulation of toxic petroleum hydrocarbons, resulting in increased physiological stresses and reproductive failures

Long-term or sublethal effects of oil also include delayed and depressed egg laying, reduced hatching, and reduced growth rate due to poor nutrient uptake (Hunt, 1985).

There has been no formal monitoring of the cumulative effects of OCS-related oil spills on endangered birds in the Pacific Region. However, a radio-telemetry study of brown pelicans oiled during the non-OCS *American Trader* spill of February 1990 is being conducted. Subsequent to the oil spill, these pelicans were rehabilitated and released. Preliminary results from this study are encouraging and indicate that brown pelicans may return to normal behavior patterns within 1-2 years after oiling and rehabilitation.

The OCS lessees in the Pacific Region are required by stipulation to maintain state-of-the-art oil-spill containment and cleanup equipment onsite and in the vicinity of exploratory drilling, in accordance with the requirements of USCG Notice No. 5740. Lessees are further required to provide suitable means of deployment and personnel trained in deployment and use of oil-spill containment equipment. To manage larger spills, lessees are required to maintain state-of-the-art equipment on vessels stationed so that they can reach a spill within 2 to 4 hours. These measures protect most birds from small oil spills like those that occurred in the Pacific Region from 1987 through 1991. In fact, during this period, the populations of both the brown pelican and the least tern in California increased dramatically (D. Anderson, pers. comm. Oct. 1, 1993; Massey, 1993). To date, there remains only one documented incident of oil-spill impacts to birds in the Pacific Region that is directly attributed to OCS activities—the 1969 Santa Barbara oil spill.

Conclusion: No oiled endangered birds were reported as a result of the small OCS-related spills that occurred in the Pacific Region from 1987 through 1991. Because of the small size of these spills and their distribution over time, no cumulative effects on bird populations in southern California occurred. Because the populations of both brown pelicans and least terns in California increased dramatically from 1987 to 1991, there is no evidence that OCS-related oil spills had a long-term cumulative impact on these species in the Pacific Region during this period.

4.2B4 Marine Mammals

Marine mammals in the Pacific Region during this report period included cetaceans (whales, dolphins, and porpoises) and pinnipeds (seals and sea lions).

Effects of OCS Seismic Surveying: During the OCS exploration phase, the lessee conducts seismic surveys to investigate geological formations for natural gas and oil reserves. Acoustic energy is reflected off subsurface layers and recorded. The high-energy acoustical pulses used during these surveys are generated by air guns or water guns. From 1987 through 1991, 44 seismic surveys were conducted in the Pacific Region. Surveys during this period were conducted off northern California, in the Santa Barbara Channel, and off San Diego. Seismic surveys in these areas were conducted 5-95 km offshore and averaged 640 km of trackline (with a range of 30-3,700 km). If the acoustic waves generated during seismic surveys exceed the ambient "background" noise, they may produce sublethal effects in marine mammals by interfering with communication or by altering behavior.

The effects of seismic noise on baleen whales are discussed in section 4.2B3 under endangered whales. No direct testing of the effects of seismic noise on toothed whales or pinnipeds has occurred (Malme et al., 1989; Richardson et al., 1991). Since their hearing sensitivity is greatest at frequencies of several thousand Hertz (Hz) (Aubrey et al., 1988), toothed whales may be relatively insensitive to the low-frequency seismic pulses (<500 Hz) emitted by air guns (Malme et al., 1989). Although ambient sound levels in marine environments are highly variable, seismic sound pressure dissipates to under 200 dB at distances beyond 30 m from the acoustic source (Gales, 1982).

The most probable effect of geophysical noise on pinnipeds would be a temporary change in distribution away from the activities. Richardson et al. (1991) hypothesized that pinnipeds strongly attracted to an area for feeding or breeding activities would tolerate such intense impulse sounds when produced at distances greater than 5 km.

Geophysical seismic activities can result in behavioral responses in marine mammals (brief flight responses or a temporary change in direction of movement), but direct injury (physical impairment of hearing), even at a close range, is unlikely. Considering the wide range of habitat available to marine mammals and the relatively small range of potential disturbance, encounters with seismic activities are infrequent.

Conclusion: Given the findings discussed above and the limited number of seismic surveys conducted in the Pacific Region during 1987 through 1991, seismic operations had no significant effect on marine mammal populations.

Effects of OCS Support Vessel Traffic: Noise and disturbance from OCS support vessels and helicopter traffic may affect whales. Support vessels for activities in the Santa Barbara Channel and Santa Maria Basin operate out of bases in the Santa Barbara Channel; support vessels traveling to and from the four platforms in the Beta Unit operate out of Long Beach. Helicopters are routed to rigs or platforms in the Santa Maria Basin or Santa Barbara Channel from Santa Maria, Lompoc, and airports along the Santa Barbara Channel. Helicopters fly direct routes from point to point and adhere to the general FAA-recommended minimum ceiling of 1,000 feet. Support vessels average 16 trips per week per platform, helicopters 3 to 5 trips per week per platform. Noise and disturbance from helicopter and service-vessel traffic may elicit a startle reaction from marine mammals or may mask their sound reception.

The reactions of baleen whales to aircraft noises have been examined (Malme et al., 1989) and are discussed in the section on endangered whales. The responses of toothed whales to aircraft noise have not been studied systematically (Richardson et al., 1991), although the whales have been observed to dive abruptly or swim away from fixed-wing aircraft when closely approached (Malme et al., 1989). In contrast, dolphins and porpoises are indifferent to the presence of helicopters overhead at altitudes of 300-550 m (Au and Perryman, 1982; Barlow, 1988). There is no evidence that single or occasional aircraft overflights cause long-term displacement (Malme et al., 1989).

Pinnipeds are susceptible to the impacts of air traffic in coastal areas, where traffic near haulouts and rookeries may disrupt activities. Low-flying aircraft, especially helicopters, can frighten pinnipeds hauled out on beaches or offshore rocks, potentially separating pups from their mothers. If such disturbance occurs at pinniped rookeries during the pupping season, an increase in pup mortality and reduced pupping success may occur (Johnson, 1977; Bowles and Stewart, 1980). Bowles and Stewart (1980) found that California sea lions and northern elephant seals at San Miguel Island did not react to the approach of light aircraft at altitudes above 30 m and did not react to jet aircraft or helicopters above 300 m. They concluded that these species were less sensitive to aircraft noise than harbor seals.

Service vessels comprise the greatest amount of marine traffic associated with OCS activities. Toothed whales, particularly dolphins and porpoises, are well known to be attracted to vessels (Barham et al., 1980; Shane, 1980; Watkins et al., 1981; Shane et al., 1986; Richardson et al., 1991). Most studies of the effects of vessel disturbance on baleen whales have focused on gray whales.

In December 1991, in conjunction with the installation of offshore pipelines and power cables for the SYU expansion project in the western Santa Barbara Channel, Exxon was required to implement a marine mammal monitoring program (Exxon, 1991; Woodhouse and Howorth, 1992). This program is discussed in section 4.2B3 under the effects of OCS support vessel traffic on endangered whales.

Under the authority of the Marine Mammal Protection Act, the NMFS proposed regulations for providing greater protection to whales, dolphins, and porpoises. These regulations are also discussed in section 4.2B3.

There is no evidence that routine OCS air traffic affected marine mammals in the Pacific Region during the 1987-1991 period. The conclusion is that, based on experiences in southern California, accidental collisions between marine mammals and support-base traffic are unlikely events. Although large cetaceans were occasionally struck by freighters or tankers and sometimes by small recreational boats, no such incidents were reported with crew or supply boats off California (I. Lagomarsino, NMFS, pers. comm.).

Conclusion: During the report period, there was no evidence that OCS-related support vessel traffic adversely affected cetaceans.

Effects of OCS Oil Spills: From 1987 through 1991, 15 OCS-related oil spills (>1 bbl) occurred in the Pacific Region, spilling a total 187 bbl of oil. The spilled oil contacted a very small percentage of habitat available to marine mammals. The only OCS-related oil spill in the Pacific Region known to contact marine mammals was the 1969 Santa Barbara Channel spill.

Several recent studies (reviewed by Geraci and St. Aubin, 1985b; Geraci, 1990) have attempted to determine the possible effects of oil on marine mammals. These studies have focused on the marine mammals' ability to detect and avoid oil; behavioral effects; thermal effects; tissue damage due to oil contact, inhalation and ingestion of oil, and toxicity and bioaccumulation.

Baleen whales can detect oil (Geraci, 1990). It also has been experimentally demonstrated that dolphins can detect and will avoid a surface layer of oil (Geraci et al., 1983; Smith et al., 1983; St. Aubin et al., 1985). However, a field study of bottlenose dolphin reactions to the non OCS-related *Mega Borg* oil spill in the Gulf of Mexico in 1990 indicated that dolphins can detect but do not avoid contact with most oil types except mousse (Smultea and Würsig, 1991). The dolphins did not avoid slick oil in most circumstances, although there was some evidence of a change in behavior in response to slick oil: interindividual spacing and respiration rates tended to decrease as though the dolphins were huddling closer together and staying below the surface longer.

Pinnipeds, including California sea lions, possess reasonably acute vision (Nachtigall, 1986) and a good sense of smell. Thus, they appear to be physiologically and anatomically able to detect the presence of oil (St. Aubin, 1990). Although there is some evidence of oil-spill avoidance by phocid seals (Mansfield, 1970; Cowles et al., 1981), a number of observations have been made of seals, sea lions, and fur seals swimming in oil slicks (e.g., Geraci and Smith, 1976; Reiter, 1981; Shaughnessy and Chapman, 1984).

Spilled oil could interfere with the normal behavior of pinnipeds such as the California sea lion. For example, oiling of pinniped fur could mask olfactory recognition of young pups by nursing females. The sense of smell has been reported to be important in mother/pup bonds in harbor seals (Renouf et al., 1983) and is probably important in other seals as well.

The most serious potential impact of direct oil contact on pinnipeds is the effect on thermoregulation. Most adult pinnipeds rely on a thick layer of subcutaneous fat for insulation and appear to be little threatened by the thermal effects of fouling (St. Aubin, 1990). However, newborn pups, which have little subcutaneous fat and are thought to rely greatly on their natal coat for insulation, may be more vulnerable to the thermoregulatory impacts of oiling. Fur seals, like sea otters, depend on their dense underfur for insulation and, thus, are very vulnerable to the thermal effects of oiling. Petroleum removes the natural oils that waterproof the pelage of fur seals and sea otters (St. Aubin, 1990). Kooyman et al. (1976; 1977) demonstrated that fouling with oil can double the rate of heat transfer through fur seal pelts.

Fouling by oil may also interfere with locomotion, especially in young animals. Gray seal pups whose flippers had been stuck to their sides by oil have been observed drowning after oil spills in the Atlantic (Davis and Anderson, 1976; St. Aubin, 1990).

The toxic, volatile fractions of crude oils could irritate and damage a marine mammal's soft tissues, with effects as severe as death in extreme cases (Geraci, 1990; St. Aubin, 1990). An animal unable to leave the area during the first few hours after a spill, when vapor concentrations are still high, would inhale vapors and might be harmed. In their study of the reactions of bottlenose dolphins to the 1990 *Mega Borg* spill, Smultea and Würsig (1991) believed that the greatest threat to the dolphins was exposure to toxic source fumes. Würsig (1990) has suggested that, based on life history patterns, pelagic delphinids are behaviorally vulnerable and sensitive to oil-spill-related stress.

No direct studies have been made on the effects of hydrocarbon inhalation on pinnipeds. Based on indirect data from immersion studies and data extrapolated from terrestrial mammals, St. Aubin (1990) concluded that, although it is unlikely that petroleum vapors could become sufficiently concentrated to present a threat to most pinnipeds, brief exposure to relatively low concentrations might be fatal to animals stressed by parasites (especially parasitic lung disease) or other metabolic disorders.

Hydrocarbons (especially low molecular-weight fractions) can also damage epidermis by removing protective lipids from the skin surface, penetrating between epidermal cells, disrupting cellular membranes, and eliciting an inflammatory response in the dermis (Lupulescu et al., 1973). Although necrotic skin is sloughed, leaving ulcers, such lesions rarely have been observed on oil-fouled seals (Geraci and Smith, 1976; St. Aubin, 1990). Eye irritation (including severe conjunctivitis, swollen nictitating membranes, and corneal abrasions and ulcers) due to exposure to oil-covered water has been experimentally demonstrated in ringed seals (Smith and Geraci, 1975); however, similar effects have been observed to occur naturally (St. Aubin, 1990).

Studies on the effect of petroleum hydrocarbons on cetacean skin have concluded that cetacean epidermis is nearly impenetrable to oil (Geraci and St. Aubin, 1982; 1985). However, it was suggested that cetaceans could consume damaging quantities of oil while feeding, although Geraci (1990) believes it is unlikely that a whale or dolphin would ingest much floating oil. Baleen whales in the vicinity of a spill are more likely to ingest oil-contaminated food (especially zooplankton, which actively consume oil particles) (Geraci, 1990). However, since the principal prey of most baleen whales have a patchy distribution and a high turnover rate, an oil spill would have to persist over a very large area to have more than a local, temporary effect. Most toothed whales and pinnipeds are mobile, wide-ranging predators feeding at the top of the food chain and are less likely to ingest oil-contaminated prey (Geraci, 1990; Würsig, 1990).

Conclusion: Despite possible effects, there is no evidence that OCS-related oil spills occurring in the Pacific Region from 1987 through 1991 affected marine mammals.

4.2B5 Marine and Coastal Birds

The coastal and offshore waters of the Pacific Region support an abundant and diverse population of birds—more than 100 species occur in the region on a regular basis. As with most coastal areas of the world, the seasonal occurrence and abundance of birds are complex and ever-changing. The bird population is dominated by birds that either move through the area during migration or spend their nonbreeding period in the area. Common marine birds of the Pacific Region include loons, grebes, shearwaters, storm-petrels, cormorants, scoters, and alcidae. The region also supports several breeding species, including the common murre, Cassin's auklet, Leach's storm-petrel, Brandt's cormorant, and western gull.

A variety of coastal bird populations occupies the sandy beaches, rocky shores, offshore rocks, and wetlands (marshes, sloughs, and bays) of the Pacific Region. Common coastal birds found within the region include waterfowl, herons, egrets, rails, plovers, sandpipers, gulls, and terns.

Effects of OCS Support Vessel Traffic: Support vessels for activities in the Santa Barbara Channel and Santa Maria Basin operate out of bases in the Santa Barbara Channel; support vessels traveling to and from the four platforms in the Beta Unit operate out of Long Beach. Helicopters are routed to rigs or platforms in the Santa Maria Basin or Santa Barbara Channel from Santa Maria, Lompoc, and airports along the Santa Barbara Channel. Helicopters fly direct routes from point to point and adhere to the general FAA-recommended minimum ceiling of 1,000 feet. Support vessels average 16 trips per week per platform, helicopters 3 to 5 trips per week per platform. Vessel and helicopter traffic associated with OCS activities can cause disturbance to birds, especially during the nesting season.

The MMS provided OCS lessees in the Pacific Region with an ITL for protecting marine mammals and birds from aircraft. This ITL and effects from low-flying aircraft are discussed earlier in the section 4.2B3(c).

Helicopter and vessel traffic can affect birds in areas where these sources of disturbance are rare and the birds have not had an opportunity to acclimate to them. Effects studies in the Arctic indicate that the arctic tern, black brant, and common eider all show lower nesting success in disturbed areas (Gollup et al., 1974). In addition, Schweinsberg (1974) reported that snow geese were particularly sensitive to aircraft disturbance during the premigratory staging period in the Arctic. Repeated aircraft flights (not related to OCS activities) near several seabird colonies in the Bering Sea region may be one factor contributing to fewer nesting attempts and reduced reproductive success (Biderman and Drury, 1978; Hunt et al., 1978). However, effects studies by Ward and Sharp (1974) and Gollup et al. (1974) indicate that long-term displacement or abandonment of important molting and feeding areas due to occasional aircraft disturbance is unlikely.

Although no studies have been conducted on the effects of air and vessel traffic on birds in southern California, the problems observed in the Arctic and Bering Sea studies are not expected to occur in this area because air and vessel traffic are almost a constant occurrence along the coast of southern California, and most bird populations have strongly acclimated to this source of disturbance. Also, the largest and most important seabird colonies in southern California occur on the Channel Islands where air traffic is restricted to altitudes greater than 1,000 feet, a buffer considered sufficient by the FWS and CDFG to minimize potential disturbances.

Conclusion: There was no evidence that OCS-related aircraft and vessel traffic affected marine and coastal birds in the Pacific Region during the 1987 through 1991 period.

Effects of OCS Oil Spills: Compared to other potential OCS-related impacts, oil spills, by far, can have the most serious effect on marine and coastal birds. During 1987 through 1991, there were 15 small OCS-related oil spills in the Pacific Region—ranging from 1 to 100 bbl in size. The effects on marine and coastal birds from oil contact are discussed in section 4.2B3(c).

Conclusion: Although a few birds may have been oiled from OCS spills from 1987 through 1991, none were reported. The conclusion, based on the small size of these spills and their distribution over time, is that no cumulative effects on marine and coastal bird populations in southern California occurred during this time period.

4.2C Socioeconomic Environment

There was considerable opposition to OCS Sales 91 and 95 in the Pacific Region from the public sector and State and local governments. The issues raised at public meetings sponsored by the Pacific Region included:

- potential for oil spills
- effects of oil and gas exploration and development on marine organisms
- effects on air and marine water quality
- conflicts between other users of waters offshore California including the military, commercial fishermen, shipping, and recreational interests
- effects on local economic conditions including increased pressure on local communities to provide services
- transportation of hydrocarbons (e.g., tankering)

The MMS attempted to address all the issues raised by holding many public scoping meetings for each sale, acknowledging the issues raised at these meetings, and thoroughly and objectively analyzing the issues in environmental impact analyses.

President Bush established a task force to collect information on OCS oil and gas development offshore California and to recommend directions the OCS Program should take. The MMS cooperated extensively with the task force by providing requested information and participating in public meetings conducted by the task force. Ultimately, the President canceled OCS Sales 91 and 95 and ordered that additional studies be completed before additional leasing activities occur in the Pacific OCS Region.

4.2C1 Public Services and Community Infrastructure

As of December 1991, the Pacific Region had 24 offshore facilities: 20 producing platforms, 1 oil and gas processing platform, 2 nonproducing platforms with jackets only, and 1 OS&T vessel. Platform Gail off Southern California was brought on line during 1987-1991.

Employment associated with natural gas and oil development and production can affect the demographic and economic conditions of local communities. Variations in the labor demands associated with these activities can influence housing and other public service requisites in adjacent local communities. The large short-term labor demands accompanying the construction of facilities usually bring many new workers and families into local communities. Facilities in the production phase typically employ fewer workers with different job skills than they employ in the construction phase of the project. The local communities and their infrastructure (schools, hospitals, water, roads, etc.) may be affected by the number of new residents, the demographic changes resulting from the evolution of job skills required, and the perceived lack of predictability of the development and production processes.

As a consequence of the offshore petroleum industry's relatively small size and its location in a very large and diverse metropolitan area, the industry has a very modest influence on countywide or regional employment and demographic statistics. The MMS-funded study *Cumulative Socioeconomic Impacts of Oil and Gas Development in the Santa Barbara Channel Region: A Case Study* (Centaur Associates, Inc., 1984) observed that from 1960 to 1983 Santa Barbara and Ventura Counties experienced significant economic and demographic growth.

> Oil and gas development played a relatively small role in that growth, and, in the absence of oil and gas development, the growth in the two counties would have been very similar. Federal oil and gas activity was shown to have a slightly greater impact than State oil and gas activity, although neither can be construed as a dominant force in the development of Santa Barbara and Ventura Counties (p. 19).

To monitor the effects of the offshore industry's development projects on the local infrastructure, the counties of Santa Barbara, Ventura, and San Luis Obispo joined together to implement a socioeconomic monitoring and mitigation program. Developers of natural gas, oil, and pipeline projects were required to participate in this program by providing data on a number of social variables, (e.g., number of employees, number and age of dependents, place of residence, schools attended, etc.). The intent of the program was to monitor continuously the local socioeconomic impacts associated with in-migration to the community during the development phase of those projects and to assess the compensation needed to offset adverse impacts as they occur.

During the period 1986-1990, the offshore petroleum industry paid $2.55 million and $1.39 million in compensation to Santa Barbara and Ventura Counties, respectively (Patton, 1993). San Luis Obispo County, initially involved in the program, was dropped from active participation because of a low impact of offshore oil operations anticipated for that county (Molotch and Woolley, 1993). An evaluation of this socioeconomic mitigation and monitoring program found that less money was paid for mitigation than expected (Molotch and Woolley, 1993). The reason for lower payments was that actual effects from offshore oil development were less severe than anticipated.

Conclusion: During the period of 1987 through 1991, the OCS-related activities in the Pacific Region modestly affected local communities and their infrastructure.

4.2C2 Coastal Land Use

From 1987 through 1991, OCS activities used existing coastal facilities in the Pacific Region: 15 onshore oil and gas processing facilities, and 12 refineries (tables 4.2-4 and 4.2-5).

The California Coastal Commission-approved local coastal programs, and Port Master Plans, regulate land use within the coastal zone. Any development (industrial or other) occurring within the coastal zone is subject to the land-use controls of the local jurisdictions as stated in their local coastal programs. Development outside the coastal zone is subject to the land-use controls of the local jurisdictions, as specified in their general plans or area-specific plans.

Land use in the coastal zone is further controlled by county or city regulations. For example, the cities of Morro Bay and San Luis Obispo and the county of San Luis Obispo have passed ballot measures which either (1) prohibit any onshore facilities that would directly or indirectly support OCS activity, or (2) require voter approval of such facilities prior to issuance of required local permits. In June 1988, San Luis Obispo County voters rejected a development plan application by Shell Western Exploration Production Inc. (San Miguel Field) by voting 55 percent to 45 percent against the subject ballot measures. In Santa Barbara County, any modification of existing facilities will occur according to existing policies and/or within previously designated industrial areas.

Conclusion: Because OCS activities used existing coastal facilities during 1987 through 1991, no change from previous land-use conditions occurred in the Pacific Region.

Table 4.2-4. Onshore Natural Gas and Oil Processing Facilities in the Pacific Region, 1987 through 1991

Facility	Location
Santa Maria Crude Refinery	Guadalupe, San Luis Obispo County
Battles Gas Processing Plant	Santa Maria, Santa Barbara County
Lompoc Separation Facility	Lompoc, Santa Barbara County
Point Conception Separation and Treatment Facility	Government Point, Santa Barbara County
Gaviota Separation and Treatment/Gas Processing Facility (Chevron)	Gaviota, Santa Barbara County
Gaviota Separation and Treatment/Gas Processing Facility (ARCO)	Gaviota, Santa Barbara County
Offshore Storage and Treatment Facility	Offshore Santa Barbara County
POPCO Separation and Treatment/Gas Processing Facility	Santa Barbara County
Las Flores Separation and Treatment/Gas Processing Facility	Santa Barbara County
Dos Pueblos Separation and Treatment Facility	Dos Pueblos, Santa Barbara County
Ellwood Separation and Treatment Facility	Ellwood, Santa Barbara County
Carpinteria Separation and Treatment/Gas Processing Facility	Carpinteria, Santa Barbara County
La Conchita Separation and Treatment Plant	La Conchita, Ventura County
Rincon Separation and Treatment/Gas Processing Facility	Rincon, Ventura County
Mandalay Beach Separation and Treatment/Gas Processing Facility	Mandalay Beach, Ventura County

Source: MMS Pacific Region, April 1994

Table 4.2-5. Onshore Natural Gas and Oil Refineries in the Pacific Region, 1987 through 1991	
Facility	**Location**
ARCO	Carson, Los Angeles County
Chevron	El Segundo, Los Angles County
Edgington Oil	Long Beach, Los Angeles County
Fletcher Oil and Refining Co.	Carson, Los Angeles County
Huntway Refining Co.	Wilmington, Los Angeles County
Mobil Oil Corporation	Torrance, Los Angeles County
Shell Oil Co.	Wilmington, Los Angeles County
Texaco Refining and Marketing	Wilmington, Los Angeles County
Union Pacific Resources Co.	Wilmington, Los Angeles County
Unocal Corp.	Wilmington, Los Angeles County
Unocal Corp.	Santa Maria, Santa Barbara County
Western Oil Refining, Inc.	Long Beach, Los Angeles County

Source: MMS Pacific Region, April 1994

4.2C3 Commercial Fisheries

Annual landings of commercial fish and invertebrate species at southern California ports vary considerably from year to year. During the period 1982 through 1985, commercial fisheries landings were dramatically affected by a major El Niño event, which resulted in substantial declines in landings throughout the region. The lowest volume of commercial harvest occurred in 1985 when approximately 200 million pounds of fish were landed at southern California ports (USDOC, NOAA, NMFS, 1986). Since 1985, commercial fish landings have shown a general increase from the low levels associated with the El Niño. During the period 1987 through 1991, landings in southern California were highest in 1988, with more than 315 million pounds landed (CDFG, 1989). They were lowest in 1991, with approximately 204 million pounds landed (USDOC, NOAA, NMFS, 1992). These fluctuations in total commercial fish landings are independent of oil and gas operations in the region; they reflect weather conditions, market demand, harvest regulations, and resource availability.

The MMS requires OCS operators to conduct activities without interfering with fishing activities. Some MMS mitigation measures include notifying fishermen and the USCG about proposed activities, structures, or debris that might affect fishing operations. The Joint Oil/Fisheries Liaison Office and the Joint Oil/Fisheries Committee, established in 1983, address and resolve conflicts between the fishing and oil industries. Additionally, the California Sea Grant Extension Program publishes a monthly Oil and Gas Project Newsletter for Fishermen and Offshore Operators.

Effects of OCS Seismic Surveying: From 1987 through 1991, 44 seismic surveys were conducted in the Pacific Region. Surveys during this period were conducted off northern California, in the Santa Barbara Channel, and off San Diego. Seismic surveys in these areas were conducted 5-95 km offshore and averaged 640 km of trackline (with a range of 30-3,700 km).

Geophysical survey activities may impede or prevent commercial fishing, damage fishing gear or boats, disperse target species of fish, harm or kill fish, or affect fishermen's catches. Fishermen may be forced to move from a seismic survey area to other fishing grounds. This move could potentially result in lost fishing opportunity, increased competition among fishermen, reduced catches, loss of fishery product markets, and attendant economic losses. In addition, commercial dive fishermen may experience health and safety problems when exposed to loud noises produced during underwater seismic surveys. Possible effects of OCS seismic surveying on fish populations and behavioral patterns are discussed in section 4.2B2.

The available evidence indicates that the abundance of fish in an area near seismic operations could be reduced, especially if several seismic vessels operated in a relatively small area. However, further field experiments are required to elucidate the spatial and temporal extent of the effects of sounds from air gun arrays on fish catches.

Conclusion: No significant cumulative effects of seismic surveys on commercial fisheries were documented for the Pacific Region during 1987 through 1991.

Effects of OCS Platform/Structure Emplacement: By the end of this report period, the Pacific Region had 24 offshore facilities (20 producing platforms, 1 oil processing platform, 2 non-producing platforms with jackets only, and 1 OS&T vessel). The placement of these facilities precluded an estimated 23 mi^2 from commercial fishing in the Pacific Region during this time (table 4.2-6). The eastern Santa Barbara Channel area has the highest density of platforms and pipelines in the Pacific Region and is also an area important to commercial trawling of ridgeback and spot shrimp and California halibut.

Commercial fishermen assert that considerable areas in the Santa Barbara Channel have been excluded from historical trawling grounds because of OCS natural gas and oil structure emplacements and debris.

Table 4.2-6. Estimated Area Lost to Commercial Fishing in the Pacific Region, 1987 through 1991	
Species	Area Lost To Commercial Fishing (Square Miles)
California Halibut	9
Ridgeback Shrimp	9
Spot Prawn/Rockfish	2
Rockfish	3

Although the area occupied by a platform is usually about 0.3 mi^2 (USDOI, MMS, 1992b), each platform can exclude fishing activity from about 1 mi^2 surrounding the platform. The exclusion area may be larger for some types of fishing (e.g., trawling and drift gill netting) and smaller for other types (e.g., hook and line fishing). If platforms are located close together (and especially if gathering lines connect the platforms), the area of spatial exclusion may be larger than the sum of the areas excluded by individual platforms. The trawl fishery is particularly affected because trawlers lose the capability to fish between platforms outside individual platform buffer zones. The presence of debris from natural gas and oil operations and other sources may also exclude additional fishing areas or increase the operational hazards to trawlers.

Operations involved in installing or removing platforms may exclude fishermen from a relatively larger area (about 3 mi^2) around each platform. However, such temporary operations last only about 3-6 months and do not substantially increase the long-term cumulative impacts on commercial fisheries.

From 1987 through 1991, one platform and two platforms jackets were emplaced on the OCS. Chevron began installing Platform Gail in April 1987 and completed the task at the end of August 1987. In consultation with FWS and CDFG, the MMS required the operator, Chevron, to modify its oil-spill contingency plan. These modifications required the plan to protect endangered species and to maintain 1,500 feet of open-ocean boom, an open-ocean oil skimming device, and 15 bales of oil-sorbent material on the platform. In June and October 1989, Exxon installed two platform jackets in its SYU. To minimize conflicts with commercial fishermen, Exxon paid fishermen not to fish in the vicinity of the jackets for 3 years. The MMS required Exxon to do the following:

- submit a plan detailing how claims by commercial fishermen would be handled
- conduct a postinstallation geophysical survey around the platform site and along the pipeline and power cable corridors to detect any debris that could affect commercial fishing operations

- recover any detected debris
- identify and locate debris that was not recovered and explain why it was not recovered
- use construction techniques that minimize turbidity
- conduct a fisheries and wildlife training program for all Exxon offshore personnel
- list conditions when pipelaying operations would not be conducted
- prepare a detailed anchoring plan to reduce impacts to hard substrate features

Conclusion: OCS platform and rig emplacement caused limited local impacts on commercial fisheries in the Pacific Region from 1987 through 1991 because the areas occupied by platforms were no longer accessible to trawl fishermen.

Effects of Offshore Use Conflicts: Some OCS-related activities and equipment may cause damage or loss of commercial fishing gear and vessels. Service vessels traversing crab or lobster fishing areas, trap storage areas, longline fishing areas, or set or drift gillnet fishing areas also may damage or destroy fishing gear. Centaur Associates (1981) conducted an extensive assessment of space-use conflicts between the fishing and petroleum industries. The authors indicated that the impacts, although typically localized and limited, included exclusion from fishing areas, vessel and gear damage, and short- and long-term effects on fish stocks.

Under Title IV of the OCSLA Amendments of 1978, commercial fishermen can file claims for compensation for fishing gear and vessel damage or loss caused by OCS natural gas and oil operations. The Fishermen's Contingency Fund compensates commercial fishermen for these economic losses. Fishermen's claims for such losses decreased substantially during 1990-1991 as OCS natural gas and oil activity decreased. During this period, the Fishermen's Contingency Fund received 44 claims in the Pacific Region and reimbursed commercial fishermen $177,440 (table 4.2-7).

Table 4.2-7. Fishermen's Contingency Fund Claims in the Pacific Region, 1987 through 1991

Fiscal Year	Number of Claims	Dollar Amounts
1987	11	50,845
1988	12	51,096
1989	14	55,123
1990	2	2,736
1991	5	17,640

The MMS requires operators to conduct activities in such a manner as to avoid undue interference with fishing activities. Mitigation measures include those listed at the beginning of this section on commercial fisheries and those under the "Effects of OCS Platform/Structure Emplacement."

Conclusion: No significant cumulative impacts on commercial fisheries occurred in the Pacific Region from 1987 through 1991 due to uncompensated economic losses resulting from OCS-related offshore use conflicts.

Effects of OCS Pipeline Construction: A total of 194 miles of OCS pipelines was constructed in the Pacific Region through 1991, 29 of which were constructed during 1987 through 1991. To reduce the danger of rupture during earthquakes, pipelines on the Pacific OCS are not buried. Offshore pipeline installations may cause temporary impacts by foreclosing the use of pipeline corridors and adjacent areas to commercial fishing during construction. Such impacts are usually minor and tend to disappear once construction activities are completed. On the other hand, anchor scars and mud mounds created by lay barges along construction corridors may impact trawl fishing for several years. However, once pipelines are in place, they often function as artificial reefs and attract fishery resources. Commercial fishermen may continue to trawl in such areas despite the danger of snagging on a pipeline.

During 1987 through 1991, commercial fishing operations experienced problems with the Grace-to-Hope pipelines. In 1980, Chevron U.S.A. Inc. installed these 10-inch and 12-inch pipelines in the Santa Barbara Channel. Anchor scars and mud mounds created by the lay barge along much of the 11.5- by 1-mile construction corridor precluded the area to halibut and ridgeback shrimp trawlers due to mudding of gear. In 1983, experimental trawling indicated that the area was fishable. However, during 1987 through 1991, commercial fishermen continued to experience problems when trawling in the vicinity of the Grace-to-Hope pipelines.

The cause of the trawling gear damage associated with the Grace-to-Hope pipelines was unclear. The damage could have been caused by thin sheet metal protrusions associated with field joint outer wraps that were delaminating from the underlying coating along most of each pipeline's length. Or, the heavy steel doors of the trawls could have collided with the pipelines and gouged out areas of the concrete pipe coating, thereby leaving sharp edges potentially capable of snagging a trawl net. Since early 1991, Chevron worked with the Southern California Trawlers Association and the Joint Oil/Fisheries Liaison Office to negotiate acceptable measures to compensate trawl fishermen for the adverse effects of the Grace-to-Hope pipelines.

In conjunction with the installation of offshore pipelines and power cables for the SYU expansion project in the western Santa Barbara Channel, the MMS required Exxon Company U.S.A. to adopt several mitigating measures. These measures were designed to ensure that no significant hazards to trawling are present or likely to occur in the future as a result of the pipeline span rectification portion of the SYU project in the "fan channel" area.

Commercial fishermen can submit claims for gear damage or loss in the vicinity of any pipeline to the Fishermen's Contingency Fund as well as to any OCS operator responsible for the damage or loss.

Conclusion: No significant cumulative, uncompensated impacts to commercial fishing from OCS pipeline construction were documented in the Pacific Region from 1987-1991.

Effects of OCS Oil Spills: No major OCS-related oil spills occurred in the Pacific Region during 1987 through 1991, although there were 15 small spills ranging from 1 to 100 bbl.

Impacts to commercial fisheries can occur if oil spills decrease the abundance of important species or reduce fishing efforts. Decreased abundance can result from fish kills due to toxic effects, avoidance of contaminated habitat, or impairment of reproductive success. Reduction of fishing effort may be caused by fishermen's avoidance of spill areas to prevent fouling of boats and gear, confinement to port by oil-spill containment equipment, or inability to market catches because of tainting or contamination (particularly of shellfish). Commercial fishermen can suffer severe economic losses from any of these impacts, depending on such factors as the size and duration of the spill, the size and importance of the habitat affected, the relationship of the spill to major commercial fishing grounds, and the vulnerability of each species during the season when the spill occurs. Significant impacts to fisheries can also cause economic losses for numerous support industries.

Many oil-spill prevention and response measures are in effect to protect the marine environment and fishermen. In the event that commercial fishermen sustain economic losses, they may apply for compensation to the Fishermen's Contingency Fund, the Fishing Vessel and Gear Damage Compensation Fund, and/or the Offshore Oil Spill Pollution Fund.

Conclusion: Insignificant cumulative impacts on commercial fisheries occurred from 1987 through 1991 in the Pacific Region from uncompensated economic losses associated with OCS-related oil spills.

4.2C4 Recreation and Tourism

The California coastline is an outstanding visual resource of great variety, grandeur, contrast, and beauty and contributes to the economic success of the tourist industry. The following major recreational activities occur along the coastline:

- sightseeing
- birdwatching
- swimming
- diving
- beachcombing
- whalewatching
- wading
- surfing
- picnicking
- boating
- sunbathing
- sportfishing

Recreational use along the beaches of southern California is the most intense of all areas on the West Coast. Santa Monica Bay has the highest density of use, with beach attendance exceeding 75 million per year (Granville Corporation, 1981).

Important recreational resources within the area include the Santa Monica Mountains National Recreation Area (located from Point Mugu to Santa Monica) and the Channel Islands National Marine Sanctuary. The sanctuary boundaries encompass the ocean area extending from the mean high-tide line to a distance of 6 nautical miles around San Miguel, Santa Rosa, Santa Cruz, Anacapa, and Santa Barbara Islands. The islands themselves are not part of the sanctuary, but constitute the emergent portion of the Channel Islands National Park.

Tourism in the California coastal counties generated more than $3 billion in income in 1982 (Dornbusch and Company et al., 1987). Although this value only considers the spending of visitors from outside each of the coastal counties, it shows the magnitude of the recreation industry in the California coastal area.

One measure of tourism is hotel occupancy rates. The trends in annual occupancy rates for 1987-1991 (Santa Barbara Visitors Bureau, pers. comm., October 7, 1993) were as follows:

- Along the south coast of Santa Barbara County, there was a decrease from 72.7 percent to 64.9 percent.
- Nationally, hotel occupancy rates fell by 3 percent.
- California showed a decline of 5.9 percent.

Although most of the OCS natural gas and oil activities occur offshore southern Santa Barbara County, there is no evidence to demonstrate that OCS-related activities adversely affected tourism in that area. Previous studies (Dornbusch and Company et al., 1987) found no significant tourism impacts related to OCS activities. The decline in hotel occupancy rates recorded in California during 1987-1991 reflects a national trend and probably represents the effects of weak economic conditions.

Effects of OCS Platform/Structure Emplacement: During the period from 1987 through 1991, one platform (Gail 1987) and two jackets (Heritage and Harmony, 1989) were installed in the Santa Barbara Channel area. Platform Gail is located approximately 10 miles from shore, and Heritage and Harmony are located 6 and 8 miles from shore, respectively. The average distance from shore for OCS platforms in the Pacific Region is 6.3 miles.

Platform installation and operations affect recreational resources by inserting a manmade structure into a 0.3 $mile^2$ area which had previously been open water; this area may have been suitable for boating or sailing. These platforms (primarily those within 5 mi of the coast) are seen from the scenic highways and have altered the visual environment along the coast.

Two studies (Granville Corporation, 1981; Dornbusch and Company et al., 1987) considered the visual effects from offshore platforms. These studies determined impacts using the expected change in the aesthetic resource of the area based on OCS development. The effects were based on the platforms (singly or in groups of four) being 3 miles from shore. Platforms located from 3 to 6 miles would result in a noticeable change in the local scenery. While platforms between 6 and 10 miles would result in a slight change, beyond 10 miles no change was considered since the platform would be barely discernible to the naked eye.

The only platform installed in the Pacific Region from 1987 through 1991 was approximately 10 miles offshore and approximately 7 miles from Anacapa Island. The presence of this platform caused, at the most, only a slight change in the local scenery.

Natural gas and oil platforms also offer habitat to a number of recreationally important fish species. Although much of the seafloor in the Southern California OCS Planning Area is a featureless combination of mud and sand, a natural gas and oil platform provides a solid structure where invertebrate organisms and fish concentrate. Recreational fishermen are aware of this relationship and actively pursue fish in the vicinity of existing OCS facilities.

Conclusion: Studies on tourism and recreation did not indicate any significant changes in usage due to offshore platform emplacement from 1987 through 1991. In addition, platform emplacement was beneficial to recreational fishing.

Effects of OCS Oil Spills: During the period 1987 through 1991, 15 OCS-related oil spills (>1 bbl), totalling 187 bbl, occurred in the Pacific Region. None of the spilled oil reached shore.

Oil spills may affect beaches, making them unpleasant or unusable, thus reducing the economic intake for local recreation-oriented businesses. The loss is usually immediate but does not extend beyond the removal of the oil (Restrepo et al., 1982). The severity of the oil-spill impact on recreational resources depends on several factors, such as the following:

- season
- area affected
- aesthetic quality of the affected coast
- oil retention of the area contacted
- amount of oil contacting the shoreline
- effectiveness of cleanup operations

The OCS lessees in the Pacific Region are required to maintain state-of-the-art oil-spill containment and cleanup equipment onsite and in the vicinity of exploratory drilling and development and production operations. In addition, suitable means of deployment and personnel trained in deployment and use of this equipment must be available. To manage larger spills, lessees are required to maintain state-of-the-art equipment on vessels stationed within a 2- to 4-hour travel time from the spill.

The volume of oil spilled from OCS-related activities during 1987 through 1991 in the Pacific Region was small (187 bbl). As a comparison, natural seeps in the Santa Barbara Channel normally discharge between 40 and 670 bbl of oil per day. The largest of the natural seeps are located off Coal Oil Point, within a mile or two of beaches near the University of California campus in Santa Barbara. These large seeps have been reported to discharge as much as 900 bbl of oil per day (Wilson et al., 1974). However, recreational use of Santa Barbara County beaches has been unaffected by these seeps.

Tourism has not decreased in Santa Barbara and Ventura Counties. Instead, there has been a marked increase in tourism (about 350 percent) in this area (Dornbusch and Company et al., 1987; Santa Barbara Chamber of Commerce, 1971), which has the most intense offshore natural gas and oil activity in the Pacific Region. The only recorded decrease in tourism occurred during the oil shortage of 1974 and, to a lesser degree, in 1979.

Conclusion: Because OCS-related oil spills occurring in the Pacific Region from 1987 through 1991 were all small (187 bbl total) and did not reach shore, no effects on recreation and tourism were noted.

4.2C5 Archaeological Resources

To minimize impacts to archaeological resources in the Pacific Region, the MMS funded three baseline studies: (1) An Archaeological Literature Survey and Sensitivity Zone Mapping of the Southern California Bight, (2) California Outer Continental Shelf Archaeological Resource Study from Morro Bay to the Mexican Border, and (3) California, Oregon, and Washington Archaeological Resource Study. These studies attempted, through the compilation of information on known archaeological resources and the use of predictive models, to identify areas of the OCS where there is a high probability of archaeological resources. These baseline studies are updated for each lease sale. The updates include analysis and synthesis of data—archaeological, geological and geophysical—generated since the preparation of the original study (or the last update).

The Archaeological Resource Stipulation (established 1973) requires the lessee to conduct lease-specific archaeological resource surveys in those areas having a high probability for archaeological resources. If a potential archaeological resource is identified, the operator is required to avoid the potential resource or to conduct additional studies to determine its significance. Where possible, operators have chosen to avoid the potential resources identified.

Effects of OCS Platform/Structure/Pipeline/Onshore Facilities Emplacement: From 1987 through 1991, one platform (Gail, 1987) and two jackets (Heritage and Harmony, 1989) were installed in the Santa Barbara Channel area. Platform Gail is located approximately 10 miles from shore, and the two jackets (Heritage and Harmony) are located 6 and 8 miles from shore, respectively. Approximately 29 miles (46 km) of OCS pipeline were constructed during 1987 through 1991 in the southern Santa Maria Basin and the Santa Barbara Channel. Also, one onshore construction project occurred in the Pacific Region from 1987 through 1991. In 1988, Exxon began construction of a separation, treatment, and gas processing plant at Las Flores Canyon/Corral Creek in Santa Barbara County as part of their SYU project.

To date, 36 archaeological surveys have been conducted in the Pacific Region. All operators avoided the potential resources identified.

Conclusion: Because the archaeological stipulation precluded OCS-related activities in areas of archaeological resource potential, adverse effects from OCS factors were prevented from 1987 through 1991.

Effects of OCS Oil Spills: During 1987-1991, 15 OCS-related oil spills (>1 bbl) were recorded in the Pacific Region. These spills totaled 187 bbl of oil.

The severity of the oil-spill impact on archaeological resources depends on a number of factors: type of oil, location, and weather and sea conditions. In the open ocean and in moderate to high seas, spills are dispersed and weathered by physical and biological processes such as evaporation, oxidation, emulsification, and uptake and metabolism by marine organisms. Much of the oil is dispersed throughout the water column over several days to weeks.

Although there are some historic shipwrecks in Federal waters, most archaeological sites are relatively close to shore. Therefore, a spill contacting the shoreline has a greater chance of affecting these sites, resulting in a temporary degradation of the viewshed of any historic or prehistoric sites in the contact area. If the spilled oil sinks and settles to the bottom, submerged sites could be affected, resulting in hydrocarbons contamination of the organic site material.

The crisis atmosphere during a spill's cleanup period could result in accidental damage and/or total destruction of unidentified sites. Careful coordination during cleanup operations would provide a measure of protection for this resource.

The OCS lessees in the Pacific Region are required to maintain state-of-the-art oil-spill containment and cleanup equipment onsite and in the vicinity of exploratory drilling and development and production operations. In addition, suitable means of deployment and personnel trained in deployment and use of this equipment must be available. To manage larger spills, lessees are required to maintain state-of-the-art equipment on vessels stationed so that they can reach a spill within 2 to 4 hours.

The 15 oil spills occurring in the Pacific Region from 1987 through 1991 were all small (totalling 187 bbl), and none of the spills reached shore. Surface slicks may occur as a result of small spills, but beach fouling is unlikely due to wind and wave dispersal, distance from shore, and the effectiveness of cleanup operations.

Comparatively, natural seeps in the Santa Barbara Channel normally discharge between 40 and 670 bbl of oil per day. The largest of the natural seeps is located off Coal Oil Point, within 1-2 miles of beaches near the University of California campus in Santa Barbara. These large seeps have been reported to discharge as much as 900 bbl of oil per day (Wilson et al., 1974).

Conclusion: There were no discernible effects from OCS-related oil spills on archaeological resources during 1987-1991.

4.3 Alaska Region

The Alaska Region comprises 15 planning areas within three subregions: Gulf of Alaska, Bering Sea, and Arctic. (fig. 4.3-1). More detailed information relating to the OCS Program can be found in *Alaska Update: September 1988-January 1990, Outer Continental Shelf Oil and Gas Activities* (Gould et al., 1990) and *Alaska Update: February 1990-April 1992, Outer Continental Shelf Oil and Gas Activities* (François and Gächter, 1992). There were five OCS lease sales held in the Alaska Region from 1987 through 1991 (table 4.3-1).

Table 4.3-1. Alaska OCS Lease Sales, 1987 through 1991

		Sale Offering			Bids Made			Leases Issued	
Sale	Date	Area	Tracts	Acres	Number	Tracts	Acres	Tracts	Acres
97	3/16/88	Beaufort	3,344	18,277,806	276	218	1,198,099	202	1,110,721
109	5/25/88	Chukchi	4,566	25,631,122	653	351	1,982,565	350	1,976,912
92	10/11/88	No. Aleutian	990	5,603,472	31	23	121,754	23	121,754
124	6/26/91	Beaufort	3,417	18,556,976	60	57	277,004	57	277,004
126	8/28/91	Chukchi	3,476	18,987,591	30	28	159,213	28	159,213

Source: Adapted from *Federal Offshore Statistics: 1991* (USDOI, MMS, 1992a)

Prelease and postlease activities took place in the Alaskan OCS Planning Areas between 1987 and 1991. During the 5 years covered by this report, the following OCS-related activities occurred in the Alaska Region:

- 74 G&G exploration permits were issued
- 11 exploratory wells were drilled
- 10,000 bbl of drilling muds and cuttings were discharged
- 5 bbl of lubricating oil were spilled

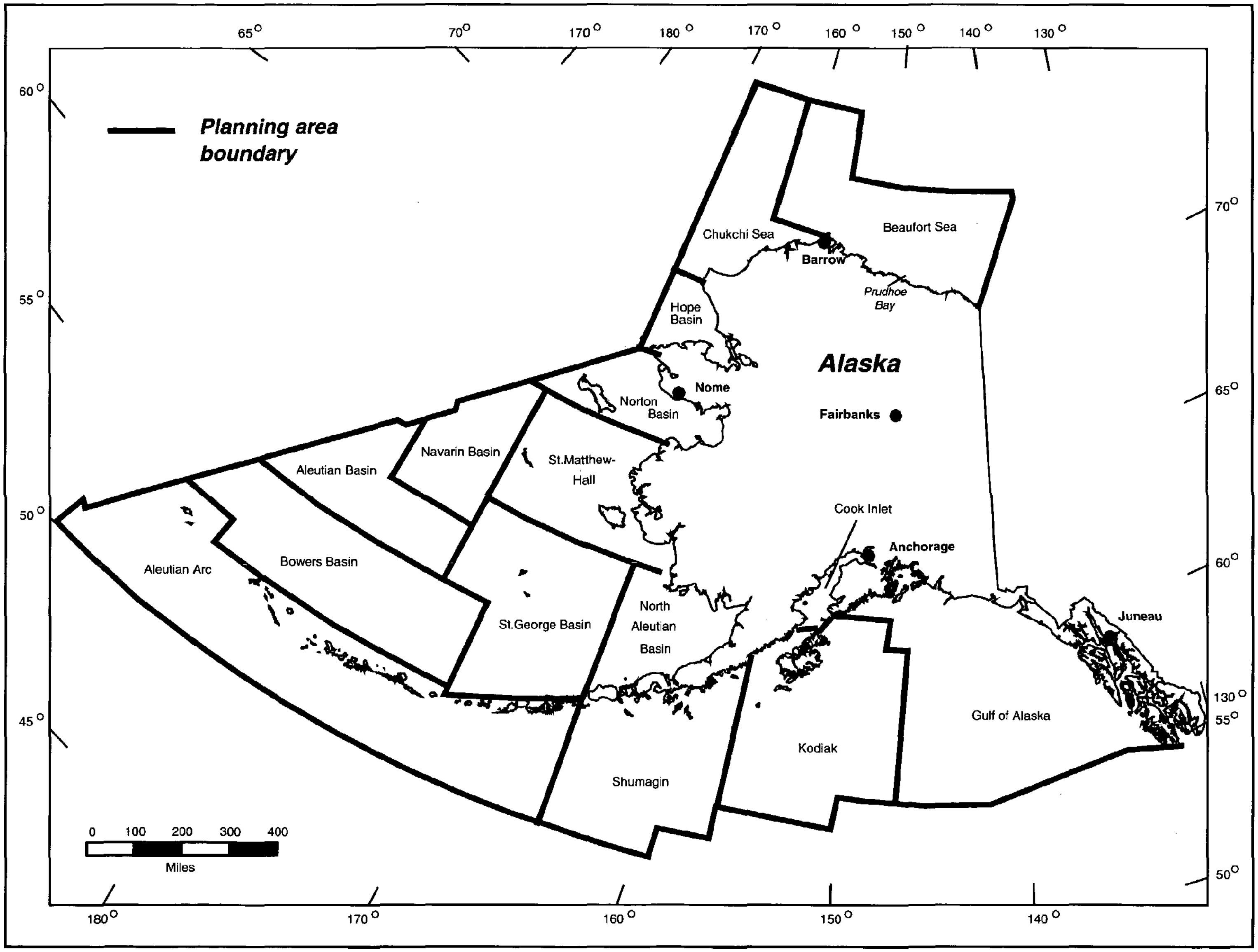


Figure 4.3-1. Alaska OCS Planning Areas

4.3A Physical Environment

4.3A1 Water Quality

Table 4.3-2. OCS G&G Permits Issued by the Alaska Region, 1987 through 1991	
Year	**Number**
1987	18
1988	13
1989	17
1990	19
1991	7
Total	**74**

Source: Adapted from *Federal Offshore Statistics: 1991* (USDOI, MMS, 1992a)

Effects of OCS Geological Sampling: Geological sampling activities in the Alaska Region were limited: 74 OCS G&G permits were issued from 1987 through 1991 (table 4.3-2), and approximately 27,000 trackline miles of seismic survey were run.

Water quality around the immediate site is altered and degraded in several ways during geological sampling activities. Bottom sampling and shallow coring cause sediment suspension and an increase in turbidity; however, the amount of disturbance is minimal and limited to the immediate area of operations. Sediment levels return to background levels within several hundred meters from the activity.

Conclusion: Given the limited amount of geological sampling conducted in the Alaska OCS Region from 1987 through 1991 and the temporary and localized nature of the effects associated with bottom sampling and coring, no significant cumulative effects on water quality occurred.

Effects of Offshore Discharge of Routine OCS Operational Wastes: Drilling of 11 exploratory wells from 1987 through 1991 (table 4.3-3) discharged approximately 10,000 bbl of drilling muds and cuttings in the Alaskan OCS.

All discharges from OCS natural gas and oil exploration, development, and production facilities are regulated by the EPA. The EPA issues a general NPDES permit that establishes relevant effluent limitations, prohibitions, reporting requirements, and other conditions. During the period covering 1987 through 1991, the EPA issued 75 NPDES permits regulating OCS activities in the Chukchi and Beaufort Seas.

When discharged into the water column, drilling fluids typically form two plumes. The heavier materials settle to the seafloor slightly downcurrent of the discharge point. Deposition occurs within 100 m of the discharge point, with trace-metal and suspended-solid concentrations generally reaching background levels within 1,000-2,000 m (ECOMAR, Inc., 1980; NRC, 1983). Because of dilution, dispersion, and settling, the effects of drilling muds and cuttings on water quality in the Alaska Region were limited to the immediate vicinity of the 11 drilling sites (figs. 4.3-2 and 4.3-3).

During drilling, contaminated water quality exists only during periods of actual discharge and rapidly dissipates on completion. Studies conducted in the Alaska Region (Houghton et al., 1980; ECOMAR, Inc., 1983; Jones and Stokes Associates, Inc., 1983, 1990; Tetra Tech, 1984) indicate that the effects of drilling muds and cuttings discharges on water quality are temporary, limited in spatial extent, and not accumulative.

Table 4.3-3. Alaska OCS Drilling History, 1987 through 1991

Sale	Prospect/Unit	Block	Operator	Spud Date	P&A Date[1]
BEAUFORT SEA					
BF	Tern	788/789	SWEPI	02-10-87	05-10-87
87	Aurora	890	Tenneco	11-02-87	08-31-88
87	Belcher	767	Amoco	09-06-88	08-29-89
71	Fireweed	883	ARCO	10-19-90	12-24-90
97	Diamond	620	Chevron	09-11-91	10-05-91
97	Galahad	412	Amoco	09-18-91	10-14-91
87	Cabot	644	ARCO	11-01-91	02-26-92
CHUKCHI SEA					
109	Klondike	287	SWEPI	07-09-89	09-14-89
109	Burger	718	SWEPI	09-29-89	08-22-90
109	Popcorn	150	SWEPI	10-14-89	09-23-90
109	Crackerjack	718	SWEPI	09-23-90	08-31-91

[1] Plugged and Abandoned Date

Source: Adapted from *Alaska Update: February 1990-April 1992* (François and Gächter, 1992)

Conclusion: Because of the limited amount of exploratory drilling that occurred during the 1987-1991 period and the limited and temporary nature of effects from muds and cuttings discharges, impacts on water quality in the Alaska Region were minimal.

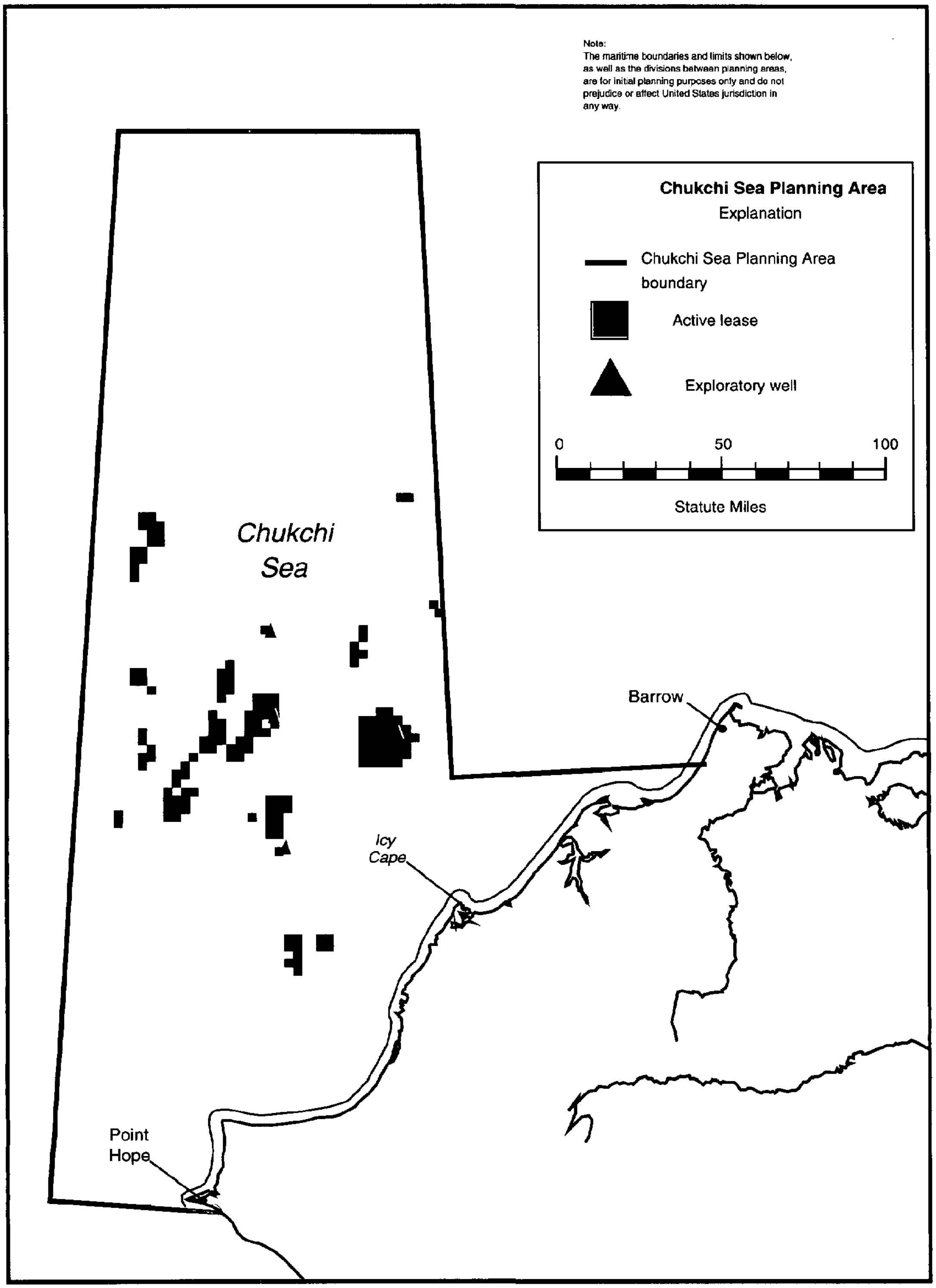


Figure. 4.3-2. Chukchi Sea Planning Area, Status of Leases and Exploration Activities, 1987 through 1991

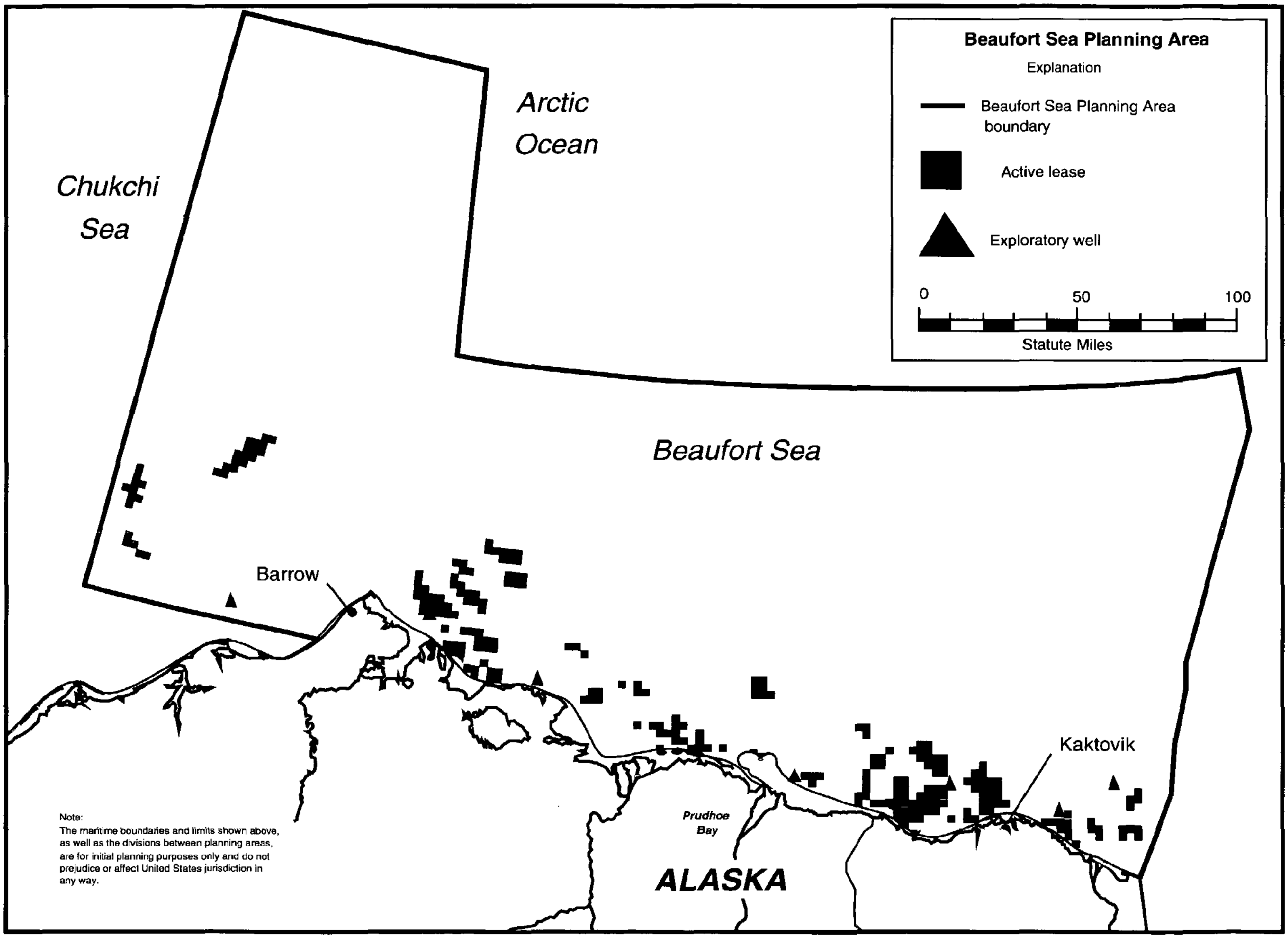


Figure. 4.3-3. Beaufort Sea Planning Area, Status of Leases and Exploration Activities, 1987 through 1991

Effects of OCS Oil Spills: During 1987 through 1991, one OCS-related oil spill (totalling approximately 5 bbl of oil) occurred when a helicopter sling hook broke and dropped a pallet of lubricating oil. The oil, which landed on solid ice, was completely removed.

Conclusion: No impacts on water quality from OCS oil spills in the Alaska Region from 1987 through 1991 were identified.

4.3A2 Air Quality

Air quality is affected by emissions from all direct and support activities for OCS natural gas and oil operations, such as exploratory drilling, construction, development and production operations, and support craft activities.

Emissions from all direct and support activities for OCS natural gas and oil operations affect air quality. In the Alaska Region, OCS emissions came from the drilling units and vessel traffic associated with drilling 11 exploratory wells in the Beaufort and Chukchi Sea Planning Areas. No more than three exploration wells were drilled in any given year, and the drill sites were located from 9 km to over 31 km offshore. As shown in table 4.3-4, these diesel-burning vessels emitted NO_x, TSP, VOC, SO_2, and CO.

Table 4.3-4. Emissions from Alaska OCS-Related Exploration Activities, 1987 through 1991

Pollutant	Activity Emissions (tons)
NO_x	445
TSP	92
VOC	15
SO_2	41
CO	80

Onshore areas adjacent to the Beaufort and Chukchi Sea Planning Areas are Prevention of Significant Deterioration (PSD) Class II areas—where air quality is relatively pristine, with ambient air concentrations of criteria pollutants far below the NAAQS and the State of Alaska air quality status and regulations (EPA, 1978). Within these areas, there are only a few small, localized emissions from widely scattered sources, principally from diesel-electric generators in small villages. The only major local sources of industrial emissions are adjacent to the Beaufort Sea Planning Area in the Prudhoe Bay/Kuparuk oil-production complex—the subject of two monitoring programs (Environmental Research & Technology, Inc., 1987; Environmental Science and Engineering, Inc., 1987). In each program, two monitoring sites were selected:

one was influenced by emissions from nearby industrial activities, and the other was more representative of air quality in the general Prudhoe Bay area. The results demonstrated that, generally, most ambient-pollutant concentrations met the ambient-air-pollution standards, even for sites deemed subject to localized industrial sources.

From 1987 through 1991, OCS-related emissions in the Alaska Region did not exceed pollutant exemption levels. Less than 5 percent of the allowable PSD increments for any criteria pollutant were used. In fact, criteria pollutant concentrations in the existing ambient air of onshore areas remained well below the NAAQS.

During this time, only one OCS-related oil spill (totalling approximately 5 bbl of oil) occurred. The oil, which was being transported via helicopter, landed on solid ice and was completely removed. As a result, no oil-spill impacts on air quality were identified in the Alaska Region.

Conclusion: Related emissions from OCS activities did not exceed pollutant exemption levels, and the amount of air pollutants from OCS-related activities reaching the Alaskan shores was spatially and temporally negligible.

4.3B Biological Environment

4.3B1 Lower Trophic Organisms

Lower-trophic-level organisms in the Beaufort and Chukchi Seas are categorized as planktonic (living in the water column), epontic (living on the underside of sea ice), or benthic (living on or in the sea bottom), depending on their general location (USDOI, MMS, 1990a).

The planktonic communities in these regions comprise phytoplankton and zooplankton. Abundance of phytoplankton appears to be greatest in nearshore waters with decreasing numbers offshore. Zooplankton communities found by Johnson (1956) were richer in the Chukchi Sea and western part of the Beaufort Sea—possibly reflecting the shallower depths in the west.

Epontic communities are composed of those plants and animals living on or in the undersurface of sea ice. The epontic communities are made up of microalgae (pennate diatoms and microflagellates). Microalgae are found in sea ice as it forms in the fall, but the origin of the cells is not known (Horner and Schrader, 1982). One theory is that those species that eventually thrive in the ice may be present in low numbers in the water column and may be incorporated into the ice as it forms (Horner and Schrader, 1982).

The benthic communities are made up of macrophytic algae (large seaweeds), benthic microalgae, bacteria, and benthic invertebrates (mysids, amphipods, copepods, isopods, and euphausiids). Boulder Patch, the largest kelp community, occurs in Stefansson Sound near the coast in the central portion of the Beaufort Sea Planning Area (Dunton and Schonberg, 1981; Dunton, 1984). In general, macrophytes are most likely to occur in areas free from ice gouging or landfast ice, and where hard substrates occur.

Effects of OCS Seismic Surveying: Approximately 27,000 trackline miles of seismic survey were run in the Alaska Region from 1987 through 1991. Seismic surveys use explosives and air guns as acoustical energy sources.

Since most algae do not contain critical gas chambers, effects of seismic exploration on marine plants are minor. In general, even high explosives (e.g., dynamite) have relatively little effect on marine invertebrates, presumably due to a lack of air-containing chambers such as the swim bladder of fish (Falk and Lawrence, 1973). High-level explosives have relatively little effect on other lower trophic organisms. Gowanloch and McDougall (1946), cited by Falk and Lawrence (1973), found no effect from dynamite explosions on shrimp beyond 15 m.

Conclusion: Because of the small number of seismic surveys conducted in the Alaska Region and the low occurrence of effects observed, there was little effect from these activities on lower trophic communities during 1987 through 1991.

Effects of Offshore Discharge of Routine OCS Operational Wastes: Drilling 11 exploratory wells from 1987 through 1991 (see table 4.3-3) resulted in approximately 10,000 bbl of drilling muds and cuttings being discharged in the Alaskan OCS. The discharges produced by drilling create plumes of material that disperse rapidly in the water column (NRC, 1983; Tetra Tech, 1984). Most drill cuttings land on the sea bottom within 1,000 m of the discharge point. The EPA regulates discharges by issuing NPDES permits. In fact, discharges within 1,000 m of the Boulder Patch are prohibited by the EPA Beaufort Sea NPDES permit.

More than 70 drilling fluids have been tested for their impact on lower-trophic-level marine organisms. Test results found that most water-based drilling fluids are relatively nontoxic to lower trophic forms and that little bioaccumulation of metals from drilling fluids occurs (NRC, 1983).

Conclusion: Because of compliance with NPDES regulations, and the small amount and low toxicity levels of routine OCS operational wastes, there were no measurable effects on lower trophic communities in the Alaska Region from 1987 through 1991.

Effects of OCS Platform/Structure Emplacement: All OCS-related construction from 1987 through 1991 in the Alaska Region was restricted to the temporary placement of 11 drilling structures/vessels. However, construction and trenching associated with OCS platform placement could affect small areas of the sea bottom that support benthic invertebrates and marine plants.

Construction activities on the OCS could beneficially alter habitats of benthic or epibenthic animals and plants. Platforms, and to some extent causeways, add a three-dimensional structure to the environment, which may provide habitat for refuging fishes or for invertebrates and plants requiring hard substrate or sediment. On the other hand, organisms that rely on soft substrates could be adversely affected when the sea bottom is altered for platform and pipeline construction. The more mobile organisms tend to avoid these areas of disturbance.

Trenching can affect marine organisms by the following means (Starr et al., 1981; Lewbel, 1983):

- physically altering the benthic environment
- increasing sediments suspended in the water column
- displacing sediments and smothering some benthic organisms
- altering water currents by modifying benthic topography
- killing some organisms directly through mechanical actions

Conclusion: Despite possible effects, construction and trenching activities associated with drilling 11 OCS exploration wells in the Alaska Region during 1987-1991 had little impact on lower-trophic-level communities because of the small area affected by OCS platforms, the widespread distribution of natural benthic habitat, and the beneficial effects of platform habitat for many organisms.

Effects of OCS Oil Spills: From 1987 through 1991, one OCS-related oil spill occurred when a helicopter sling hook broke and dropped 5 bbl of lubricating oil. The oil, which landed on solid ice, was completely removed.

Conclusion: The one OCS-related oil spill that occurred in the Alaska Region during the report period did not affect the lower-trophic-level organisms.

4.3B2 Fish Resources

The fish resources occurring in the Chukchi and Beaufort Seas fall into three basic categories: freshwater species that make relatively short seaward excursions from coastal rivers, anadromous species that spawn in freshwater and migrate seaward as juveniles and adults, and marine species that complete their entire lifecycle in the marine environment.

Freshwater fish that venture into the coastal waters are found almost exclusively in fresh or brackish waters extending offshore from major river deltas. These species include arctic grayling, round whitefish, and burbot. Anadromous species found in nearshore waters include Pacific salmon (pink and chum); arctic char; arctic, least, and Bering cisco; rainbow smelt; and humpback and broad whitefish. Also, sockeye, coho, chinook, and king salmon; arctic lamprey; inconnu; and nine- and three-spine stickleback are occasionally found in Alaskan coastal waters. The marine fishes of this area include arctic staghorn; fourhorn, shorthorn and twohorn sculpins; arctic and saffron cod; Canadian eelpout; and arctic flounder.

Effects of OCS Seismic Surveying: During the period 1987 through 1991, there were approximately 27,000 trackline miles of seismic surveys conducted in the Alaska Region.

Seismic surveys that employ air guns, or their close equivalents, have only a limited areal/time-disturbance effect on fish. Experiments testing the effects of air guns on caged coho salmon smolts found no harmful effects (Weaver and Weinhold, 1972). Also, air guns had little effect on even the most sensitive fish eggs at distances of 1.5 m from the discharge source and were not observed to have any effect on larvae. The disturbance from the acoustic energy generated during the survey may disperse fish from the immediate area of the survey line and may cause a temporary cessation of feeding (Skalski, Pearson, and Malme, 1992). However, these impacts probably would occur only during the minutes when the acoustic energy source is strongly perceived by the fish.

Conclusion: The limited seismic surveys conducted on the Alaskan OCS from 1987 through 1991 caused only temporary, minimal disturbances to fish.

Effects of Offshore Discharge of Routine OCS Operational Wastes: From 1987 through 1991, 11 OCS exploratory wells discharged approximately 10,000 bbl of drilling muds and cuttings offshore Alaska. The EPA regulates these discharges through NPDES permits. In fact, the Beaufort Sea NPDES permit prohibits drilling discharges within 1,000 m of the Boulder Patch.

Drilling discharges (muds, cuttings, fluids, wastes, and sometimes formation waters) can alter the benthic habitat for demersal fish. In the water column, these discharges can affect water quality to the detriment of demersal, semi-demersal, and pelagic finfish. However, a number of studies, conducted in different areas of the OCS, showed that drilling discharges affect only very limited areas (Jones and Stokes Associates, 1983; Dames and Moore, 1978; Neff, Bothner et al. 1989; Menzie, 1982) over very short time periods (usually only during the discharging).

Conclusion: Drilling discharges from the 11 exploratory wells in the Alaska Region transpired outside the times and locations of fish occurrence and had virtually no adverse impacts on them.

Effects of OCS Oil Spills: From 1987 through 1991, one OCS-related oil spill (totalling approximately 5 bbl of oil) occurred when a helicopter sling hook broke and dropped a pallet of lubricating oil. The oil, which landed on solid ice, was completely removed. As a result, there were no impacts on Alaska Region fish resources from this spill.

Conclusion: Despite the possible effects, the 5 bbl of oil spilled during Alaskan OCS activities from 1987 through 1991 did not affect demersal, semi-demersal, or pelagic fish that inhabit or migrate through Alaskan OCS waters.

4.3B3 Endangered or Threatened Species

Species inhabiting the Alaskan OCS that are listed as endangered or threatened include whales (blue, fin, humpback, gray, right, bowhead, sei, and sperm); birds (short-tailed albatross, Aleutian Canada goose, and arctic and American peregrine falcons); and the Steller sea lion.

Between 1987 and 1991, natural gas and oil activities on the Alaskan OCS were limited to prelease and exploration operations. Exploration activities, including seismic surveys and operation of drilling rigs and support vessels and aircraft, took place in the Beaufort and Chukchi Seas, with up to three wells drilled each year. Because no OCS-related activities occurred near the short-tailed albatross, Aleutian Canada goose, peregrine falcon or Steller sea lion populations, none of these species were affected by these activities during this time. However, OCS-related activities did take place near endangered whale populations.

(a) Endangered Whales

The distribution, abundance, and behavior of bowhead whales are monitored by MMS personnel and contractor scientists through aerial surveys in the Beaufort and Chukchi Seas during each fall migration period (Treacy, 1992; Moore and Clarke, 1992). These surveys provide information on potential impacts of seismic exploration, drilling, and associated activities on migrating bowhead whales. They also provide real-time data to the MMS and the NMFS on the progress of migration for use in implementing limitations on exploratory activities. The surveys are also used to monitor temporal and spatial trends in distribution, abundance, habitat, and behaviors of these whales. In addition, underwater acoustic arrays and aerial survey grids surrounding exploratory seismic and drilling operations in the Beaufort Sea (required by the Industry Site-Specific Bowhead Whale-Monitoring Program) have been monitored for bowhead whale presence and behavior by oil industry contractors. Results from both of these programs indicate that no serious or irreparable impacts on bowhead whales due to OCS activities have occurred; however, some instances of unusual local distribution or temporary changes in behavior were observed.

The distribution of 72 bowhead whales in October 1991 near the Galahad drill site (Gallagher et al., 1992) probably was due to a combination of the ice cover and operation of the drillship and ice-management vessels, as well as two nonindustry boats. The offshore distribution of bowheads near Point Barrow and the Cabot drill site during fall 1991 (Gallagher et al., 1991) probably was not due to lease operations since the offshore migration was farther offshore all across the Alaskan Beaufort Sea in 1991 (Treacy, 1992).

The MMS has adopted several stipulations and ITL's to protect endangered species:

- the Protection of Biological Resources Stipulation (which may require surveys of biologically important areas and alteration of industry operations)

- the Oil-Spill Response Preparedness Stipulation

- the ITL *Information on Bird and Marine Mammal Protection* (which advises lessees concerning pertinent sections of the Marine Mammal Protection Act and the Endangered Species Act, the possible repercussions of disturbing wildlife, and the recommended distances to be maintained between wildlife concentrations and aircraft and vessels)

- the ITL *Information on Areas of Special Biological and Cultural Sensitivity* (which lists major wildlife concentration areas)

- the ITL *Information on Endangered Whales and MMS Monitoring Program* (which advises lessees that the MMS will continue its endangered whale monitoring program and may limit operations whenever bowhead whales are subject to harm)

- the ITL *Information on Consultation with NMFS to Protect Bowhead Whales in the Spring-Lead System* (which advises lessees that the MMS and the NMFS will review EP's to determine if endangered species consultation will be required for activities planned during the spring season)

Strict industry adherence to provisions of these stipulations and advisory measures effectively mitigate most potential impacts to these species.

Effects of OCS Seismic Surveying, Drilling, and Support Vessel Traffic: During the 1987-1991 period, MMS aerial surveys of bowhead whale distribution, abundance, and behavior in the Beaufort and Chukchi Seas (Treacy, 1992) and industry-conducted site-specific monitoring studies in the Beaufort Sea (Moore and Clarke, 1992) indicated that OCS activities had no serious or irreparable impacts on bowhead whales.

However, some instances of unusual local distribution or temporary changes in behavior were observed, as noted above.

Conclusion: While results of marine mammal monitoring programs (Gallagher et al., 1992; Brueggeman et al., 1992; Moore and Clarke, 1992; Treacy, 1992) suggest that there were some temporary impacts on local distribution and behavior of bowhead whales during fall migration periods, no loss of endangered bowhead or other whale species from OCS activities was evident. However, MMS-contracted studies comparing the behavior of eastern and western (Alaskan) arctic bowhead stocks concluded that some significant east-west differences in behavior were evident, particularly during the fall migration period. These differences may be due to the substantial level of disturbance from overall human activities in Alaskan waters (Richardson and Finley, 1989; Miller et al., 1991).

Effects of OCS Oil Spills: During the period 1987 through 1991, 5 bbl of lubricating oil were spilled as a result of Alaskan OCS activities. This oil was completely removed, and there was no documented report of this oil contacting endangered whales.

Conclusion: The small amount of lubricating oil spilled (5 bbl) was completely removed, and there were no effects from oil spills on endangered whales in the Alaska Region from 1987 through 1991.

(b) Endangered Birds

Species inhabiting the Alaskan OCS that are listed as endangered or threatened include the short-tailed albatross, Aleutian Canada goose, and arctic and American peregrine falcons.

In Alaska, the short-tailed albatross ranges from the Gulf of Alaska to St. Lawrence Island, primarily during the summer months. Known breeding populations of the Aleutian Canada goose nest on Buldir, Chagulak, Kiliktagik, and Anowik Islands (USDOI, MMS, 1984). During the fall, the geese leave the nesting islands and migrate eastward along the Aleutian Islands to staging areas on the north coast of Unimak Island. From there, they migrate directly over the North Pacific to their wintering areas (USDOI, MMS, 1984). The endangered American peregrine falcon nests on cliffs in interior Alaska, south of Seward Peninsula and Brooks Range. Threatened arctic peregrine falcons nest in the tundra regions of Alaska, north of the Brooks Range, and on the Seward Peninsula on cliffs, bluffs, and low hills (USDOI, MMS, 1992d). Peregrine falcon nest sites closest to the coast occur on shoreline cliffs from Norton Sound north to Cape Lisburne. On the North Slope, nesting sites nearest the coast occur about 20 miles inland (Ambrose, pers. comm., 1991).

The Aleutian Canada goose and arctic and American peregrine falcon populations are monitored periodically by the FWS. Marine bird monitoring sponsored by the MMS has provided baseline trend information on abundance and productivity for several key species.

In addition to these monitoring programs, the MMS adopted several stipulations and ITL's to protect endangered species (see 4.3B3(a)).

The OCS activities, and the resultant amount of oil spilled (5 bbl), were located in the Beaufort and Chukchi Seas—outside the ranges of these endangered or threatened birds.

Conclusion: Because activities associated with OCS exploration and the accidental release of 5 bbl of oil did not take place in the vicinity of Alaskan endangered or threatened bird populations during the period 1987-1991, no OCS-related effects on these species were documented.

(c) Steller Sea Lions

Steller (northern) sea lions occur over the continental shelf throughout the Bering Sea and Gulf of Alaska. Sea lion rookeries are located on the Pribilof Islands, on Amak Island north of the Alaskan Peninsula, throughout the Aleutian Islands, in the western Gulf of Alaska to Prince William Sound, and on Forrester Island in southeastern Alaska. Haulout areas are numerous throughout the breeding range, and some in the northern Bering Sea are also used. Sea lions disperse extensively throughout their Alaskan range after the breeding season.

The OCS activities, and the resultant amount of oil spilled (5 bbl), were located in the Beaufort and Chukchi Seas—outside the ranges of the Steller sea lion.

Conclusion: Because activities associated with OCS exploration and the accidental release of 5 bbl of oil did not take place in the vicinity of Steller sea lion populations during the period 1987-1991, no OCS-related effects on these species were documented.

4.3B4 Marine Mammals

Nonendangered marine mammal species occurring in Alaska include cetaceans (belukha, minke, and killer whales, and Dall's porpoise), pinnipeds (walrus and ringed, fur, harbor, spotted, ribbon, and bearded seals) and carnivores (polar bear and sea otter).

Natural gas and oil activities on the Alaskan OCS were limited to exploration operations during 1987 through 1991. These activities included seismic surveys and both floating and bottom-founded operations, with associated ice-management vessels and support and aerial survey aircraft. Exploration occurred in the Beaufort and

Chukchi Seas, with at least one well drilled each year. Oil spills associated with OCS activities in Alaska had no measurable effect on marine mammals.

Monitoring of the Gulf of Alaska harbor seal population status has recently been undertaken by the NMFS and the Alaska Department of Fish and Game (ADFG); in several locations these trend-site-monitoring efforts occur on an annual basis. The NMFS also has recently undertaken aerial and shipboard surveys for the harbor porpoise and killer whales in the coastal waters of Alaska, and recently reviewed and updated information on belukha whales in Cook Inlet. Results from surveys conducted by the NMFS, ADFG, and FWS, and from industry-sponsored site-specific monitoring efforts indicate that there were no population-level impacts on nonendangered marine mammals due to natural gas- and oil-related activities on the Alaskan OCS from 1987 through 1991.

From 1987 through 1991, one OCS-related oil spill (totalling approximately 5 bbl of oil) occurred when a helicopter sling hook broke and dropped a pallet of lubricating oil. The oil, which landed on solid ice, was completely removed. As a result, negligible impacts on marine mammals in the Alaska Region were identified.

(a) Cetaceans

Most routine OCS activities can cause adverse responses from one or more of these species through production of disturbing levels of noise, particularly from underwater and/or visual stimulus. The type and degree of response depend on the sound-level frequency and intensity, distance between individual and sound source, behavior of moving source, presence of ice, and duration of exposure. Also, plumes of drilling muds and cuttings may bury benthic prey populations, making them unavailable to foraging individuals. Oil or fuel spills may affect whales by contacting the skin, fouling the baleen, causing membrane irritation or ulceration, or causing respiratory distress from inhalation of hydrocarbon fumes. Consumption of some prey items or benthic substrate contaminated by oil spills could also impact cetaceans. The MMS uses the same stipulations and ITL's that protect endangered whales to protect the nonendangered whales.

From 1987 through 1991, MMS personnel and contractor scientists continued to monitor the distribution, density, and behavior of belukha whales through aerial surveys in the Beaufort and Chukchi Seas during each fall migration period. Within site-specific monitoring areas, these whales were observed entering and transiting the areas. Although the studies were not designed to detect short-term impacts of industrial activities, short-term deflections in the belukhas' swimming directions occurred as they encountered noise (such as icebreaker activities near drilling operations). Oil industry contractors also used underwater acoustic arrays and aerial surveys at and near seismic and drilling operations in the Beaufort to monitor belukha whale presence and behavior.

Conclusion: Results from monitoring programs indicated that OCS activities had no deleterious impacts on these whales. In fact, industrial activity does not seem to have any long-term or population-level impacts on arctic belukha whales. Other cetaceans (killer and minke whales, harbor and Dall's porpoise) in the Alaska Region were not exposed to OCS natural gas and oil activities (i.e., drilling and ice-management) during the review period.

(b) Pinnipeds

Nonendangered pinnipeds inhabiting Alaska include the walrus and ringed, fur, and harbor seals. Although no OCS leasing activity in the Gulf of Alaska occurred from 1987 through 1991, several studies on these species were conducted. Brueggeman et al., 1990, 1991, and 1992 studied walrus distribution, and the impacts of industrial activity on ringed seals in the Arctic were studied by several different investigators in the 1980's (1981-82, Kelley et al., 1988; 1985-87, Frost and Lowry, 1988). In addition, the NMFS and ADFG have increased their monitoring of harbor seal trend sites in the Gulf of Alaska since the non-OCS *Exxon Valdez* oil spill in 1989.

No OCS exploratory activity occurred in the Gulf of Alaska during the review period; thus, no effects on harbor seals from OCS-related activities occurred. Nonetheless, the NMFS and ADFG monitoring of harbor seal trend sites in the Gulf of Alaska since the non-OCS *Exxon Valdez* oil spill indicates a precipitous decline in harbor seal numbers throughout the Gulf—from approximately 25,000 seals in 1979 (Pitcher and Calkins, 1979) to about 2,500 in 1992 (T. Loughlin, oral comm., 1992).

Although fur seals were not exposed to OCS gas- or oil-related activities, they are still considered depleted. However, it is questionable whether the population is stable or still in decline. The causes of decline and depletion are unknown but have not been linked to OCS natural gas and oil activities.

Walrus studies (Brueggeman et al., 1990, 1991, 1992) indicate that in 1989, 1990, and 1991, walrus were primarily associated with the presence of pack ice and showed no major shifts in distribution in response to industrial activities. However, they did show some reaction to icebreaker activity. Most reactions occur at distances less than 0.93 km.

Studies on ringed seals (Kelley et al., 1988; Frost and Lowry, 1988) indicated that seismic activities had variable impacts on seals in their lairs, leading in some cases to abandonment of the lair, while in others there was no apparent impact. Some seals were affected up to 150 m from the seismic lines. However, monitoring efforts indicated no broad-scale impact from these activities on ringed seal abundance and distribution in the Beaufort Sea.

Conclusion: Because no OCS exploratory activity occurred in the Gulf of Alaska during 1987 through 1991, no effects on harbor seals occurred. In addition, the causes of decline and depletion of fur seals are unknown but were not linked to OCS natural gas and oil activities.

Monitoring efforts indicated no broad-scale impact from OCS-related activities on ringed seal abundance and distribution in the Beaufort Sea. However, studies indicated some walrus reaction to icebreaker activity.

(c) Carnivores

The sea otter and the polar bear are nonendangered carnivorous marine mammals inhabiting areas in Alaska. Sea otters range from the tip of the Aleutian Islands east to Prince William Sound. Polar bears regularly occur only as far south as the Bering Strait and St. Lawrence Island. In both the Beaufort and Chukchi Seas, polar bears follow the receding pack-ice edge northward in spring and early summer and southward as ice forms in the fall.

From 1987 through 1991, natural gas and oil activities on the Alaskan OCS were limited to exploration operations. These activities have included seismic surveys and both floating and bottom-founded drilling operations, with the associated ice-management vessels as well as support aircraft. Exploration has occurred in the Beaufort and Chukchi Seas, with at least one well drilled each year.

Sea otter populations were not exposed to industrial activity along their ranges within the Alaskan OCS during 1987 through 1991. The FWS is in the process of completing their Statewide surveys for sea otters; as yet, these survey results are incomplete. Polar bears were exposed to OCS natural gas and oil activities in the Arctic—in both the Chukchi and Beaufort Seas. Polar bears have been associated with the pack ice and along the shear zone and have occurred in the vicinity of drilling activity.

Effects of OCS Drilling and Support Vessel Traffic: In 1989, 1990, and 1991, site-specific monitoring for polar bears in the Chukchi Sea was performed in conjunction with OCS exploratory activities (Truett, 1993). These bears have responded variably to these activities—by being attracted to them or by exhibiting avoidance response. Polar bears have shown a short-term avoidance response to some icebreaker activity and will exhibit a flight response to low-flying aircraft.

Conclusion: The polar bear population exposed to OCS activities in the Arctic exhibited no population-level impacts, but individual polar bears showed short-term avoidance or attraction to these activities.

Effects of OCS Oil Spills: From 1987 through 1991, one OCS-related oil spill (totalling approximately 5 bbl of oil) occurred when a helicopter sling hook broke and dropped a pallet of lubricating oil. The oil, which landed on solid ice, was completely removed. Sea otter populations were not exposed to OCS activity along their ranges within the Alaskan OCS from 1987 through 1991. The polar bear population was not exposed to this spill.

Conclusion: Although otters are vulnerable to oil spills, the one OCS-related oil spill in the Alaska Region occurred outside of their range and was completely cleaned up. Also, this spill had no cumulative effect on polar bear population.

4.3B5 Coastal and Marine Birds

Major groups of coastal and marine birds occurring in Alaska include loons, procellariids (e.g., albatrosses, fulmars, shearwaters, storm petrels), gulls and terns, cormorants, alcids (e.g., murres, auklets, murrelets, puffins), ducks and geese, shorebirds, and raptors (eagles, hawks, falcons).

During the period from 1987 through 1991, trends in seabird abundance and productivity were monitored at St. George Island, Cape Pierce, Saint Lawrence Island, and Bluff in the Bering Sea, Little Diomede Island in the Bering Strait, and Capes Thompson and Lisburne in the Chukchi Sea. This program has been carried out under an interagency agreement with the FWS. During the period 1987-1991, a monitoring protocol for arctic waterfowl and marine birds was designed and tested in Beaufort Sea lagoons (Johnson, 1990). Initiation of a program using this protocol would provide comparative trend information on the abundance and habitat use of Beaufort Sea waterfowl and seabirds in industrial and nonindustrial areas. Marine bird use of Kasegaluk lagoon in the Chukchi Sea was also monitored during this period. Marine bird monitoring sponsored by the MMS has provided baseline trend information on abundance and productivity for several key species (Fadely et al., 1989; Mendenhall, 1991; Johnson et al. 1992).

The MMS applies the endangered birds stipulations and ITL's to protect the nonendangered coastal and marine birds of the Alaska Region. Strict industry adherence to provisions of these stipulations and advisory measures recommended by the MMS will effectively mitigate most potential OCS impacts on these species (see section 4.3B3(a)).

Most routine activities for OCS natural gas and oil operations are marginal in their potential for disturbing coastal and marine birds. The primary adverse effects on marine and coastal birds from OCS exploration and development activities could come from oil pollution of the marine environment, noise and disturbance of bird populations, and alteration of bird habitats. Operations other than aircraft-support flights did not occur sufficiently near breeding areas to result in disturbance of nesting seabirds.

Effects of OCS Support Vessel Traffic: From 1987 through 1991, activity on the Alaskan OCS was limited to prelease and exploration operations. Exploration activity, including seismic surveys and operation of drill rigs and support vessels and aircraft, took place in the Beaufort and Chukchi Seas, with up to three wells drilled each year.

Any aircraft-support flights near seabird colonies during the breeding season are likely to cause mortality if frightened nesting birds dislodge eggs or young from the ledges. Any exposed eggs and young left alone are prone to predation and weather. Routine operation of aircraft near waterfowl or raptor nesting areas may result in levels of disturbance sufficient to result in nest abandonment or decreased reproductive success.

Conclusion: Activities associated with OCS support vessel traffic did not take place near marine or coastal bird concentration areas (nest sites, feeding areas, staging areas, sheltered areas, etc.) sufficiently to result in disturbance of these species at a population level, nor have these activities been of a magnitude or duration to displace species from any areas of known or potential importance.

Effects of OCS Oil Spills: From 1987 through 1991, one OCS-related oil spill (totalling approximately 5 bbl of oil) occurred when a helicopter sling hook broke and dropped a pallet of lubricating oil. The subsequent spill, which landed on solid ice, was completely removed; thus, it did not affect any coastal or marine birds.

Conclusion: Despite the possible effects, there were no known oil-spill effects to marine and coastal birds in the Alaska Region during 1987 through 1991 from OCS activities.

4.3C Socioeconomic Environment

From 1987 through 1991 in the Alaska Region, OCS activities have proceeded only as far as the exploratory phase. Approximately 27,000 trackline miles of seismic surveys were run, and 11 exploratory wells were drilled. These activities can affect various factors of a region's socioeconomic environment, such as employment and demographics, coastal land uses, commercial fisheries, recreation and tourism, archaeological resources, and subsistence.

4.3C1 Employment and Demographics

Oil and gas exploration on the OCS, as well as onshore and offshore service facilities, may result in changes in an area's socioeconomic characteristics relating to employment and demographics. The degree to which an area is affected by these economic changes depends primarily on the size and nature of the activities and the area's economic base. Some important socioeconomic indicators are as follows:

- current levels of employment and income
- availability of housing and public services
- existing oil and gas infrastructure

Although direct OCS employment projections are based on the exploration activities themselves, estimates of income, population, and housing are based on total or new OCS resident employment using gross region- or industry-specific ratios such as:

- average payroll per employee
- population-employment ratio
- average housing units per population

Coastal towns and villages in the Alaska Region have experienced some short-term, minimal effects from OCS activities from 1987 through 1991. Warehouses, docks, and airfields were used by offshore operators. However, these facilities were generally in place and originally constructed for fishing, onshore oil production, or other industrial uses. In some cases, such facilities were improved (e.g., airport facilities at Prudhoe Bay). Since OCS activities in the Alaska Region proceeded only as far as the exploratory phase, most OCS employment during 1987 through 1991 resulted from prelease evaluations and surveys and the drilling of exploratory wells. Although these activities are labor-intensive, employment effects were limited due to the lack of development in the Alaska Region. Also, the effort expended in cleaning up the 5 bbl of OCS oil spilled during this time was negligible.

More severe impacts have been occurring to the socioeconomic environment of Alaska because of the downturn in natural gas and oil activities in Alaska rather than because of their existence. Alaskan residents, including Alaskan Natives, depend on the cash economy created by the jobs associated either directly or indirectly with the oil industry.

Conclusion: The cumulative effects of OCS activities in the Alaska Region from 1987 through 1991 on the economic dimensions of employment, income, housing, and population were minimal because OCS activities were relatively short-lived and limited to exploration only.

4.3C2 Coastal Land Uses

From 1987 through 1991, only 11 OCS exploratory wells were drilled in the Beaufort and Chukchi Seas. Onshore support for Beaufort Sea wells used existing facilities originally constructed for the development of Prudhoe Bay. Similarly, support for the Chukchi Sea wells used existing facilities. Most of the drilling units used on the Alaskan OCS were self-contained units—rigs capable of staying onsite throughout the drilling season, with a minimal need of resupply. Associated shore-based traffic was minimal and confined largely to helicopter ferry flights from established air support bases.

During 1987 through 1991, no commercially recoverable hydrocarbons were discovered, and no DPP's were filed.

Conclusion: Because existing onshore facilities were used to support OCS exploratory activities, there was no new construction of any OCS-related facilities. Thus, OCS activities during this time had a minimal effect on Alaska's coastal land use.

4.3C3 Commercial Fisheries

Impacts from OCS activities that can affect commercial fishing on the OCS include loss of fishing areas and fishing gear, loss or damage to fishing vessels, competition for support services, and oil exposure to fisheries.

Most of the Alaskan commercial fishing occurs outside of the Beaufort and Chukchi Seas. In areas on the Alaskan OCS where commercial fishing occurs, the only OCS-related activity that occurred from 1987 through 1991 was seismic surveying. Since oil-related industrial activities prior to 1987 were more intense in areas where commercial fishing is conducted on the Alaskan OCS, the following mitigation measures were developed in the form of lease sale stipulations and ITL's:

- a stipulation for an orientation program requiring the oil industry to develop a program to help prevent potential conflicts by educating support vessel operators on commercial fishing gear, areas, and seasons

- a stipulation requiring that the oil industry design pipelines and subsea wellheads so that fishing gear will not be snagged, and that their exact locations be documented so that they may be avoided

- an ITL encouraging the oil industry to keep commercial fishermen advised of industry plans and to conduct meetings with fishermen

- a publication by the Oil/Fisheries Group of Alaska (composed of fishermen and oil industry representatives) entitled *Geophysical Operations in Fishing Areas of Alaska* to improve communications and avoid potential conflicts between seismic vessel activities and commercial fishing activities

Effects of OCS Seismic Surveying: Approximately 27,000 trackline miles of seismic surveys were conducted on the Alaskan OCS from 1987 through 1991. Concerns have been expressed regarding potential conflicts between the marine geoacoustical surveys and commercial fishing operations. A major concern is the possibility that the energy pulse from acoustic arrays used in geophysical surveys may disperse fish, thereby reducing fish catches or complicating fishing procedures. A variety of studies has been conducted on commercial species off California addressing potential impacts of seismic surveying on fish larvae (Holliday et al., 1987), crab larvae (Pearson et al., 1988), and rockfish (Pearson et al., 1987). The studies showed no major effect on the subjects from exposure to air guns. Some larvae and egg mortalities occurred when sound was used at greater levels and at a closer range than would be experienced in situ. Air gun studies also demonstrated that some scattering of rockfish occurred, but the length of time they were disturbed was not determined, nor were the effects of a multiple array versus a single gun. The potential impacts of an array may be minimized by the alignment of the guns.

Conclusion: During this period (1987 through 1991), there were no reports of conflicts between commercial fishing and seismic surveying in the Alaska Region.

Effects of OCS Oil Spills: From 1987 through 1991, one OCS-related oil spill (totalling approximately 5 bbl of oil) occurred when a helicopter sling hook broke and dropped a pallet of lubricating oil. The oil, which landed on solid ice, was completely removed. Thus, there were no effects to commercial fisheries.

Conclusion: There was no report of the 5-bbl spill of lubricating oil affecting commercial fisheries in the Alaska Region from 1987 through 1991.

4.3C4 Recreation and Tourism

Both offshore and onshore recreational resources in Alaska are abundant. Tourists visit such places as Lake Clark, Lake Iliamna, Cold Bay, Bethel, Saint Paul, Saint George, Barrow, Prudhoe Bay, and many national and State parks. Fishing, hunting, boating, hiking, sightseeing, and other recreational activities are some of the many ways to enjoy Alaska's recreational resources. In addition, tourists are drawn to Prudhoe Bay to see the Trans-Alaska Pipeline System and its associated facilities. Access and transportation services to wild rivers and many lakes and scenic landscapes are limited. Tourists can see oil facilities and oil rigs when traveling by air to recreational sites. During 1987-1991, there were no substantial changes to the recreational resources from OCS-related exploration in the Alaska Region.

Most of the drilling units used on the Alaskan OCS from 1987 through 1991 were self-contained units—rigs capable of staying onsite throughout the drilling season with a minimal need of resupply. Associated shore-based traffic was minimal and confined largely to helicopter ferry flights from established air support bases.

Conclusion: Tourism has increased slightly in North Slope communities. However, because of the limited OCS-related activity during this time, the local recreation and tourism economies of Nome, Kotzebue, Point Hope, Wainwright, Kaktovik, and other communities were not affected.

4.3C5 Archaeological Resources

From 1987 through 1991, OCS operators drilled 11 exploration wells (in the Beaufort and Chukchi Seas) and ran approximately 27,000 trackline miles of seismic surveys.

OCS exploration and development activities, and any cleanup of OCS-related oil spills, can affect archaeological resources by disturbing prehistoric sites or shipwrecks.

In 1992, the MMS published an in-house study (Tornfelt and Burwell, 1992), compiled from an extensive literature search, on historic shipwrecks that occurred in Alaska from earliest Russian times (1741) to the pre-World War II era. This report summarized the historic context of Alaskan shipwrecks and provided a general discussion of shipwreck causes and locations. This comprehensive database enables the MMS to ensure that OCS activities avoid, protect, and preserve important shipwreck resources.

Prior to approval of any permits within areas considered to have potential for archaeological resources, the MMS requires OCS lessees to prepare an archaeological analysis of marine geophysical survey data. If these data indicate areas of archaeological resource potential, the OCS operator must either avoid the potential resource or conduct further investigations to determine whether an archaeological resource does exist at the site of the proposed OCS operation.

Conclusion: Given the MMS requirement to avoid archaeological resources and the limited number of OCS exploration activities conducted in Alaska from 1987 through 1991, no cumulative effects to archaeological resources were documented.

4.3C6 Subsistence

"Subsistence uses" are those traditional Alaskan uses of fish, wildlife, and vegetation for personal, family, and community needs that are accorded priority in State and Federal law. Examples include the harvesting of wildlife for domestic consumption; the harvesting of wildlife for use in traditional forms of trade and barter; and the use of by-products from such harvests (i.e., walrus ivory, whale baleen, or caribou hides) in the manufacture of traditional arts and crafts for sale. Examples of harvests that are not given subsistence priority include commercial salmon harvests, harvests for sale of salmon meat, and such "wasteful" harvests as the taking of walrus solely for its ivory.

Subsistence also has a cultural sense. Many native Alaskans express identity through convictions based on the harvest, distribution, and sharing of wild resources. This importance goes beyond the significant role of subsistence food in the local diet to include many of the shared activities and values that help hold Alaska's rural communities together (Stephen R. Braund and Associates, 1993a, b). As such, subsistence remains "a focus for maintaining a sense of identity...." (Nelson, 1965).

To date, the OCS Program in Alaska has led to only limited exploration-related activities. Prior to this review period, support bases were constructed and later decommissioned in Yakutat, Unalaska (Dutch Harbor), and on Saint Paul Island. There were no reported effects on subsistence harvests from these activities. During this review period, exploration activities in Federal waters were confined to the Arctic's Beaufort and Chukchi Seas. No more than three wells were drilled in these areas in any one year.

Mitigating measures attached to Alaskan OCS leases from 1987 through 1991 included the stipulation for OCS operators to prepare and conduct an orientation program stressing natural resources and cultural dimensions of subsistence. In the Arctic Region, a stipulation for subsistence whaling and other subsistence activities also established a process for informing subsistence whaling communities and organizations about OCS activities. This stipulation encourages lessees to conduct themselves in a responsible manner with regard to native subsistence needs and thereby avoid adverse impacts on local harvests and cultural values. The Oil/Whalers Cooperative Program for the Beaufort Sea, in effect from 1986 to 1989, between Nuiqsut and Kaktovik whaling captains and oil industry companies, is an example of such coordination and cooperation.

Of the factors capable of affecting subsistence, probably the most consequential during the review period was the need for village residents to defend the cultural and economic importance of subsistence at public hearings and meetings, the need for residents to enter into negotiations and lawsuits to defend subsistence, and even the need for residents to participate in studies on subsistence (Impact Assessment Inc., 1990a, b, and c).

Studies, meetings, and hearings carried out prior to OCS frontier leasing have been stressful for many residents of areas located near proposed lease-sale areas, requiring time commitments and travel costs to meet the timetables of outside institutions. Arctic residents have steadfastly advocated for protection of their subsistence lifestyle and have consistently expressed the view that technology is insufficient to clean up oil spilled in polar ice.

Conclusion: In the Alaskan arctic during the review period, no declines in subsistence harvest levels due to OCS oil-related activities were documented. No direct loss of subsistence resources was reported from routine and accidental OCS events in the Beaufort and Chukchi Seas, the areas where exploration drilling occurred. However, one impact of OCS activities in the Alaska Region was an increase in stress by arctic residents due to the need to repeatedly defend subsistence and to raise this concern.

4.4 Atlantic Region

The Atlantic Region comprises four OCS planning areas: North Atlantic, Mid-Atlantic, South Atlantic, and Straits of Florida (fig. 4.4-1). More detailed information relating to the OCS Program can be found in *Atlantic Update: July 1986-June 1990, Outer Continental Shelf Oil and Gas Activities* (Karpas and Gould, 1990). Because of leasing moratoria, no lease sales were held in the Atlantic Region between 1987 and 1991, but the active leases in the Atlantic Region during this time are shown in figure 4.4-2.

During the 5 years covered by this report, the only OCS-related activities that occurred in the Atlantic Region resulted from the issuance of seven G&G permits. (table 4.4-1).

Table 4.4-1. OCS G&G Permits Issued by the Atlantic Region, 1987 through 1991

Year	Number
1987	2
1988	4
1989	0
1990	1
1991	0
Total	7

Source: Adapted from *Federal Offshore Statistics* (USDOI, MMS, 1992a)

4.4A Biological Environment

4.4A1 Fish Resources

Effects of OCS Seismic Surveying: During OCS exploratory operations, deep seismic surveys are made to investigate geological formations before drilling to help locate natural gas and oil reserves. The surveys are conducted by reflecting acoustic energy off subsurface layers and recording the reflections. Seismic surveying activities in the Atlantic Region were limited from 1987 through 1991: only seven G&G permits were issued.

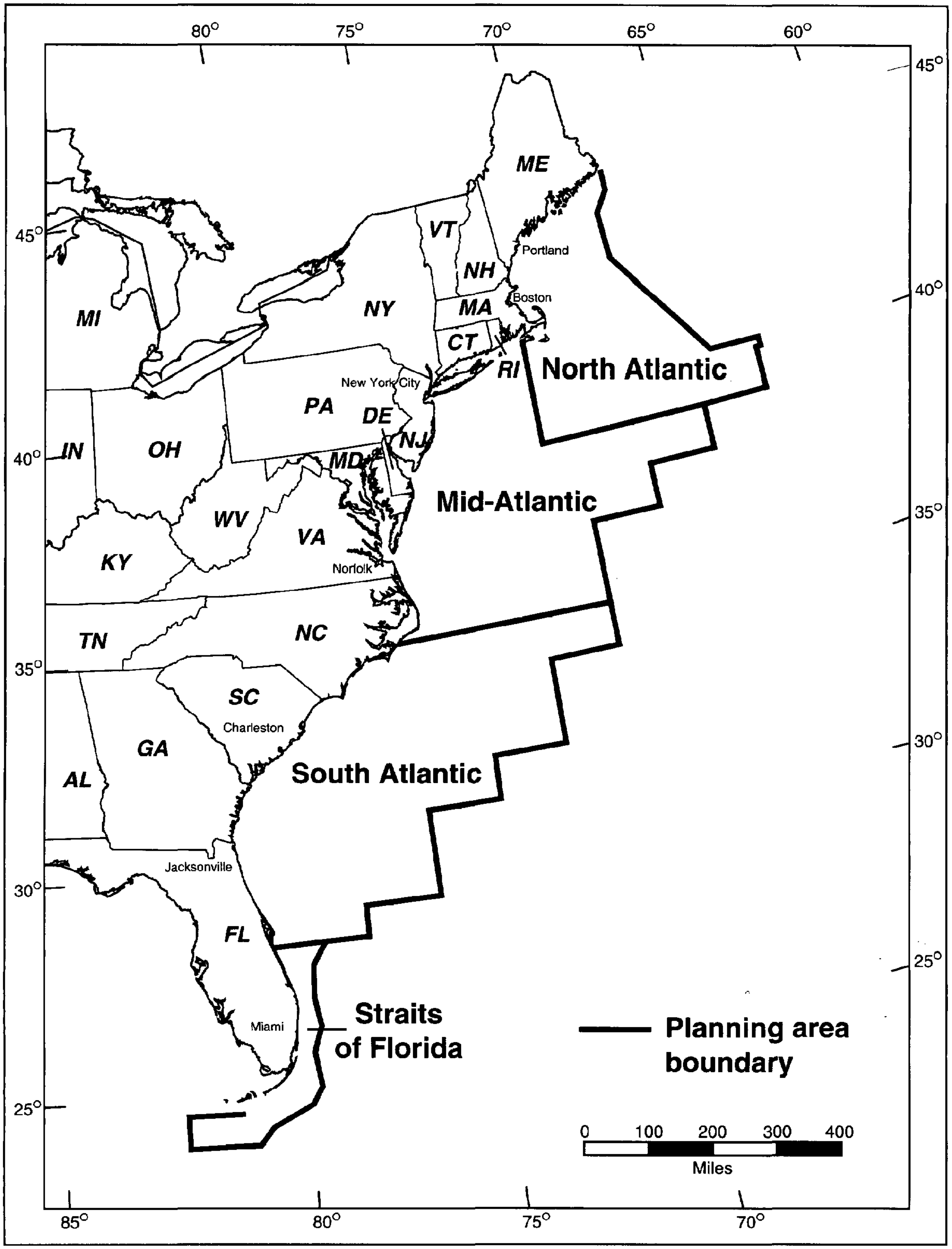


Figure 4.4-1. Atlantic OCS Planning Areas

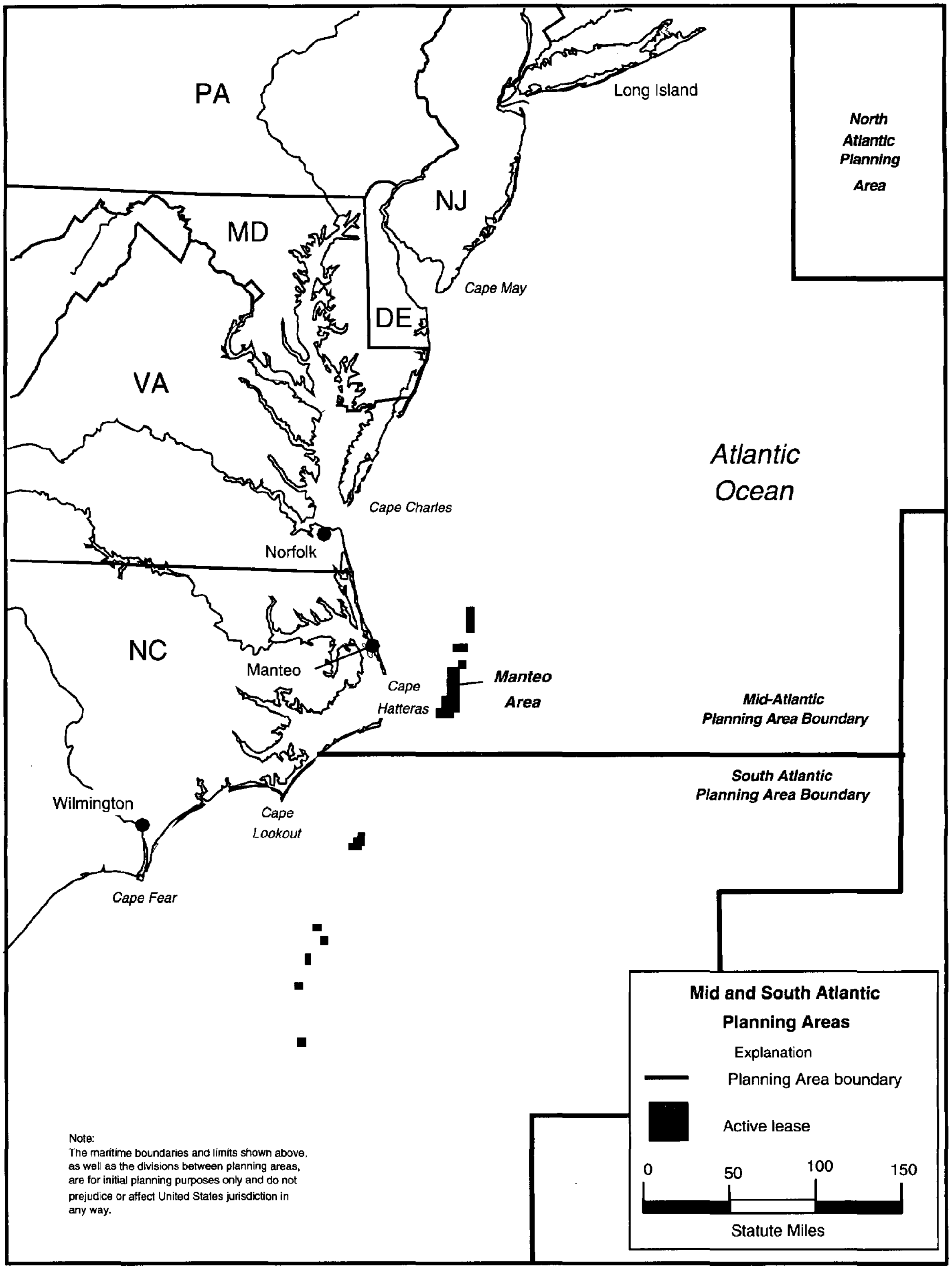


Figure 4.4-2. Mid- and South Atlantic Planning Areas, Status of Leases, 1987 through 1991

Acoustic signals from air gun or water gun arrays used during deep seismic surveys can have lethal or sublethal behavioral effects on various life stages of fish resources. These effects can be translated into effects on the fish populations as a whole and, consequently, on the fishermen who harvest those resources.

Fish hear and respond to single air gun or air gun array sources if they are exposed to moderately high sound pressure levels for at least several minutes. Pelagic schooling fish, such as herring and whiting, reacted to air-gun-generated sound pressure levels of 180-188 dB re μPa by swimming away, either to deeper water or to another area (Dalen and Knutsen, 1986; Dalen, 1973 [as cited in Battelle and BBN, 1987]; Chapman and Hawkins, 1969).

Battelle and BBN (1987) observed that several species of rockfish gave alarm and startle responses to sounds from a single air gun. Startle responses (reflexive flexions, shuddering, rapid swimming) were not observed in caged rockfish below 200 dB re μPa. The threshold for alarm responses (changes in schooling behavior, vertical distribution, and activity level) was about 180 dB re μPa. Some subtle changes in behavior became evident at 161 dB re μPa. The fish appeared to return to their previous behavior within minutes after the air gun noise ceased. However, under conditions of the experiment, the fish may have become habituated to the noise.

The limited scientific evidence available suggests that significant effects on pelagic fish eggs and larvae probably would only occur relatively close to an operating air gun array. It seems unlikely that individual eggs and larvae would normally be exposed to more than one to two shots within the near-field influence of an air gun array during an actual seismic survey because of the following:

- the spacing and pattern of shot lines during actual geophysical surveys
- the extensive spawning areas of most species compared with the survey tracklines
- the high reproductive rates characteristic of species with pelagic eggs and larvae
- the patchy distribution of pelagic eggs and larvae
- the passive movement of eggs and larvae due to ocean currents and other transport processes
- the diel periodicity and vertical migrations characteristic of the larvae of many species

The probability is extremely low that populations or year classes of adult fish would be significantly affected by mortalities of pelagic eggs, larvae, or juveniles killed during seismic surveys. Behavioral effects are difficult to quantify, difficult to interpret relative to specific impacts, and difficult to assess at the population level. However, based on the few studies conducted thus far, the major effect of seismic surveys appears to be on the behavior of juvenile and adult fish, not on their survival. Behavior tends to return to normal shortly after the noise ceases, although habituation to sustained noise may occur.

Conclusion: No significant cumulative effects of OCS seismic surveys on fish resources were documented for the Atlantic Region from 1987 through 1991.

4.4A2 Endangered or Threatened Marine Mammals

The endangered or threatened marine mammals that occur in the Atlantic Region include whales and the West Indian manatee.

(a) Endangered Whales

Five species of endangered cetaceans occur regularly on the Atlantic OCS. These are the right whale *(Balaena glacialis)*, humpback whale *(Megaptera novaeangliae)*, fin whale *(Balaenoptera physalus)*, sei whale *(B. borealis)*, and sperm whale *(Physeter macrocephalus)*. The blue whale *(B. musculus)* occurs only very rarely on the North Atlantic OCS (Mead, 1975; Cetacean and Turtle Assessment Program, 1982; Wenzel et al., 1988).

All endangered cetaceans of the western Atlantic are migratory. In particular, the four baleen species follow a predictable pattern of north to south seasonal movement. These whales usually spend the warm months offshore Maine south to Cape Cod. In winter, right and fin whales occur on the Atlantic OCS from Cape Cod south to Florida. The humpback whale does not occur on the Atlantic OCS during winter, and the winter location of Atlantic sperm, fin, sei, and right whale populations is uncertain.

Effects of OCS Seismic Surveying: During OCS exploratory operations, deep seismic surveys are made to investigate geological formations before drilling to help locate natural gas and oil reserves. The high-energy acoustical pulses used in seismic surveys are generated by air guns or water guns. From 1987 through 1991, only seven G&G permits were issued in the Atlantic Region.

If the acoustic waves generated during seismic surveys exceed ambient "background" noises, they can produce sublethal effects in endangered whales by interfering with communication or altering behavior. In controlled experiments, gray whales have exhibited startle responses, avoidance reactions, and other behavioral changes when exposed to seismic pulses at levels above 160 dB, which corresponds to a distance of about 3.6 km from an air-gun array (Malme et al., 1989). Less consistent reactions have occurred at received volume levels of 140-160 dB (Malme et al., 1983; 1984; 1989). However, Malme et al. (1989) concluded that baleen whales were quite tolerant of noise impulses produced by marine seismic exploration. Recent Endangered Species Act biological opinions issued by the NMFS for OCS activities in 1987 concluded that geophysical seismic activities may create a stressful situation but are not likely to present a barrier to whale migration.

Conclusion: Given these findings and considering the limited number of seismic surveys conducted in the Atlantic Region from 1987 through 1991, no significant cumulative effects of seismic surveys on endangered whale populations were documented.

(b) Sirenians

The herbivorous West Indian manatee *(Trichetus m. latirostris)* is the only sirenian found in U.S. waters. Population size along the southeastern Atlantic coast, and throughout this species' range, has not been adequately described. However, the total population, including those animals occurring in the Straits of Florida and western Florida, is thought to be between 700 and 1,000 individuals (USDOI, FWS, 1988). Most of the West Indian manatee population is located in eastern Florida. Not restricted to freshwater habitat, individuals of this species make seasonal migrations up the Atlantic coast. The northernmost area occupied seasonally on a regular basis is coastal North Carolina (Lee and Socci, 1989), although this species is occasionally reported as far north as the Chesapeake Bay. However, with the onset of cooler seasonal temperatures, manatees return to the warmer waters of Florida.

Conclusion: From 1987 through 1991, seven G&G permits were issued for the Atlantic Region—one permit was issued to conduct a seismic survey in the Straits of Florida. During this report period, there were no documented effects from OCS seismic surveying on this species.

4.2B Socioeconomic Environment

During the 5 years covered by this report, the only OCS-related activities that occurred in this Region resulted from the seven G&G permits issued by the MMS. The G&G surveys conducted put money into local economies through docking fees; purchase of welding and other services; and the purchase of supplies, such as fuel and food. No calculations were done to examine the impacts or any multiplier effect on the coastal economies from G&G monies that were spent. (A multiplier effect occurs when money enters a local economy and begins to exchange hands as goods or services are purchased.) However, any measurable effects would have been localized.

Although, most of the Atlantic Region was under leasing moratoria during this review period, socioeconomic effects in the Atlantic Region centered around the public and community response to the OCS Program itself. Many Atlantic coast residents feared that offshore drilling would cause catastrophic degradation of the physical and biological environments. While the OCS Program has produced large volumes of natural gas and crude oil more safely than many other sources (e.g., tanker transportation), it is perceived as a source of devastating effects on local areas. These effects include:

- air and water pollution
- hazards to biological resources
- beach fouling; changes in land and water uses
- degradation of ocean vistas, national and State parks, wildlife refuges, and other public recreation areas

Residents were particularly averse to risks over which they had little or no control or that were associated with other memorable events. Thus, the already prevalent concern that OCS natural gas and oil activities could result in a damaging oil spill was heightened by the catastrophic non-OCS *Exxon Valdez* tanker accident and the consequential damage to Alaskan coastal resources. This event reinforced many coastal residents' apprehensions about the adequacy of oil-spill prevention, containment, and cleanup equipment and procedures as well as their concerns about potential damages to highly-valued beaches, shorelines, and marine resources.

Residents also were opposed to risks that are not well understood or that are unpredictable, such as those associated with events such as earthquakes, underwater landslides, and hurricanes. Such events, they feared, posed threats to offshore exploration and development equipment and facilities, and could result in the release of hydrocarbons or the loss of life. One concern was that emergency response capabilities of local governments would be already strained during and after hurricanes, thus making it difficult to deal with an oil spill at the same time.

The fear of oil spills has grown to such an extent that many people are unwilling to accept any risk involving the possibility of an oil spill occurring. This fear has resulted in a growing resistance to OCS natural gas and oil development off the Atlantic coast. Illustrative of this point was the extensive public protest over the EP submitted by the Mobil Oil Company to drill a single well in the Manteo Prospect located 45 miles east-northeast off Cape Hatteras, North Carolina. In 1989, public hearings held for the single well proposal were attended by approximately 1,300 people.

Additional concerns included apprehensions that economic instabilities and changes in land use and onshore infrastructure would occur. A major contributor to these concerns was the boom-and-bust economies that have occurred in areas heavily dependent on natural gas and oil production. In addition, commercial fishermen often expressed concerns that their livelihood could be diminished or threatened by natural gas and oil activities. Their concerns have included effects of seismic surveys on fish eggs and larvae, the distribution and feeding of fish populations, and the exclusion of commercial and sports fishing from areas around drilling rigs.

Recreation and tourism are an important industry in many coastal areas. During the time covered by this report, many residents believed that these industries would be harmed by natural gas and oil operations. They contended that tourists would choose other areas to visit because of oil-spill risks, effects of oil rig and platform sights on coastal aesthetics, reduction in the quality of marine resources which support coastal tourism, and construction and operation of industrial support facilities onshore. Residents also believed that the locations of onshore support areas, natural gas and oil processing facilities, and transportation systems could affect coastal property values and could be incompatible with existing or planned land-use patterns. Such onshore facilities might also result in population growth that would generate additional demands on local governments for public facilities and services. Because of this fear of local growth associated with potential natural gas and oil development, some coastal communities have passed zoning laws prohibiting land use for gas or oil infrastructure.

Conclusion: The only cumulative effect from OCS-related activities spanning 1987 to 1991 on the Atlantic socioeconomic environment was the increased public concern over the OCS Program.

5.0 OCS Marine Minerals Program

5.1 Program Administration

The term "minerals," as defined in the OCSLA, includes oil, gas, sulphur, geopressured-geothermal and associated resources, and all other minerals that are authorized by an act of Congress to be produced from "public lands," as defined in section 103 of the Federal Land Policy and Management Act of 1976 (43 U.S.C. 1702). Section 8(k) of the OCSLA Amendments authorizes the Secretary of the Interior to lease minerals, other than oil, gas, and sulphur, on the OCS on the basis of competitive bidding and under such terms and conditions as may be prescribed at the time of the lease offering. Included within this authority is the Secretary's responsibility to design, implement, and manage the OCS minerals policy and development.

The basic goals of the MMS marine minerals program are to:

- evaluate and achieve the potential of the OCS as a domestic supply source for strategic and other nonenergy mineral resources
- safeguard the ocean and coastal environments by ensuring that all OCS mineral activity is environmentally sound and acceptable
- ensure that OCS mineral activities are fully coordinated and compatible with other uses of the ocean
- provide an effective consultation process for coastal States and the Federal Government regarding offshore minerals

Fulfillment of these goals provides a regulatory climate conducive to exploration and development of offshore hard minerals while safeguarding the marine environment. Accordingly, a three-tiered regulatory regime was established in 1988 and 1989 specifically for offshore minerals. These regulations govern prospecting activities (30 CFR Part 280), leasing activities (30 CFR Part 281), and operations on offshore mineral leases (30 CFR Part 282). The regulations were designed to recognize the differences between OCS activities associated with the discovery, development, and production of oil, gas, and sulfur and those associated with other minerals. Together, these three rules outline the requirements for data and information gathering ventures associated with G&G prospecting and scientific research relating to OCS hard minerals. These regulations also establish leasing procedures, basic mineral lease conditions, and general procedures to govern discovery, development, and production activities on a lease.

Within the MMS, the Office of International Activities and Marine Minerals (INTERMAR) develops policy for, and coordinates the exploration, development, and recovery of, OCS nonenergy minerals. With the cooperation of adjacent coastal States, joint Federal-State task forces assess leasing potential. If leasing is determined to be economically feasible, resource and environmental studies will follow. The task forces recommend appropriate actions to the Secretary of the Interior and the State Governor(s). Federal decisions to proceed to lease sales are made by the Secretary, with review and comment from the Governor(s).

From 1987 through 1991, INTERMAR's marine mineral activities focused on the following resources (fig. 5.1-1):

- cobalt-rich manganese crusts offshore Hawaii and Johnston Island
- phosphorites offshore North Carolina
- heavy-mineral placers and phosphorites offshore Georgia
- sand and gravel and heavy-mineral placers offshore the Gulf Coast States
- heavy-mineral placers offshore Alaska
- black sand deposits containing chromite offshore Oregon
- aggregates offshore New England

Accordingly, cooperative arrangements existed between the Federal Government and Oregon, Alaska, Hawaii, North Carolina, Georgia, the Gulf Coast States, and the New England States (fig. 5.1-1). Cumulative effects of these activities on the marine environment will be discussed at the end of this chapter.

5.2 Associated Activities

Various activities are associated with the marine minerals research program. Typical activities, which are described below, include the following:

- magnetic and high-resolution seismic profiling
- vibralifts
- heat-measuring probes
- bottom trawling and dredging
- water sampling
- submersible observations
- side-scan sonar surveys
- coring devices (including vibracores)
- benthic grab sampling
- seabird and marine mammal observations

5.2A Geophysical Equipment

Magnetic and high-resolution seismic profilers emit a signal and a sharp sound which echo back from the seabed and various reflecting surfaces beneath the seabed to give an analog of the sub-seabed in section. This profiler is used in mineral exploration to detect favorable locations for heavy mineral deposits, and in natural gas and oil exploration to detect shallow geologic hazards, such as active faults and mudslides or areas of potential instability.

Side-scan sonar is similar to the seismic profiler except that the sound does not penetrate the bottom but reflects from the seabed on either side of the towed instrument, thus producing an analog relief map up to 1 or 2 km wide.

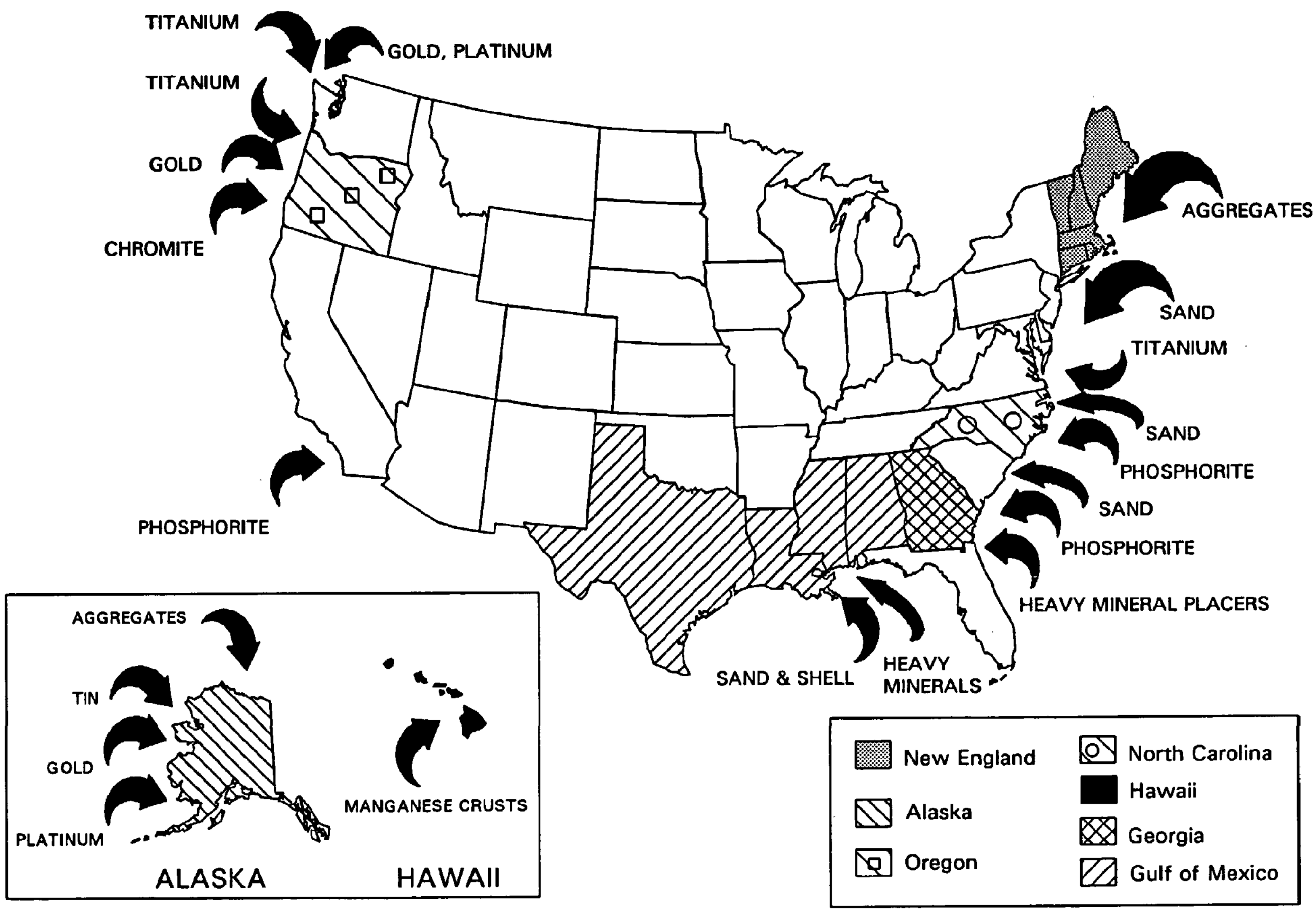


Figure 5.1-1. INTERMAR Marine Mineral Activities Conducted Under State/Federal Agreements

5.2B Sediment-Sampling Equipment

Freefall benthic grab samplers or corers may be used to take a small sample generally at a depth of 0.5 to 2 m. Samples may be about 0.5 m^3 in size. The sampling instruments may be tethered to a winch or may be of the boomerang type which releases an expendable weight of about 10 kilograms on impact and returns to the surface under its own buoyancy. Grabs are usually about 0.3 m^2 in contact area and penetrate 15-20 cm, while corers may be 5-10 cm in diameter and penetrate from less than 0.5 m to 2 m in soft sediments. These tools are virtually useless in rock or hard sediment.

Heat-measuring probes are directly towed or driven through the sediment surface. Heat conductance generally requires the measurement of heat flow through a stationary probe in the seabed. The probes may be less than 2 m long and 5 cm wide.

The vibracore/vibralift device, used in marine mineral investigations off Oregon and Georgia, is actually one drilling device that can be modified to operate in two distinct modes. The unit basically uses a pneumatic vibrator mounted to a core barrel to assist in driving the barrel into the sediment surface. As a vibracore, the unit will pull up a continuous core of sediment; as a vibralift, the unit acts essentially as a vacuum cleaner to suck up a slurry of water and unconsolidated sediment. Unlike typical coring devices, the vibracore/vibralift has achieved penetrations as deep as 6 m in soft, sandy sediments.

Bottom trawlers or dredges usually consist of a chain or mesh bag that is dragged for a distance along the seabottom to obtain samples of rock, benthic organisms, or fish that lie within the path of the device.

5.2C Biological Sampling and Observations and Water Sampling

In addition to the bottom trawling mentioned above, seabird and marine mammal observations have taken place during marine mineral research cruises to obtain a general picture of those populations in the sampling area. Deep-diving submersibles have been used to observe marine life in areas where water depth precludes the use of divers; samples have been obtained using the extendible probes of the submersibles. Water samples and chemical analysis were conducted off Alaska to determine the mercury content evident within the water column.

5.3 Summary of Marine Mineral Activities

During the period covered by this report (1987 through 1991), the MMS sponsored research efforts in the following areas to support its marine minerals program: Gorda Ridge, Hawaii, Georgia, Alaska, and Oregon. These efforts are summarized below.

5.3A Gorda Ridge

The Gorda Ridge Task Force, established in 1984, was charged with technically assessing the economic, engineering, and environmental aspects of possible ocean mining of polymetallic sulfides from the Gorda Ridge, an oceanic spreading center located offshore southern Oregon and northern California. A scientific program was funded, and logistical support was provided by the MMS, the USGS, the NOAA, and the U.S. Navy.

In the early stages, the Task Force initiated several studies to confirm the existence of active hydrothermal venting on the Gorda Ridge. One such study analyzed trace metal content in the water column overlying probable areas of hydrothermal venting. In this study, towed instruments were used to detect thermal and particle anomalies, and water samples were collected and analyzed for manganese and other trace metals. Heat-flow measurements were also obtained from three locations in the Escanaba Trough, a sediment-filled area within the Gorda Ridge. This study used a scientific temperature measuring device composed of a cylindrical weight partially filled with lead to drive a 5-meter-long pipe outfitted with thermistors into the sediment surface. This device measured the temperature differential between the bottom water and the sediment. The temperature difference, as a function of the depth, is the thermal gradient. High-heat flow values recorded during the study indicated that there were indeed areas of active hydrothermal activity.

A key component of the research work overseen by the Task Force was a series of submersible dives undertaken aboard the U.S. Navy's deep-diving submersible *Sea Cliff* in 1986 and 1988. During these dives, extensive deposits of massive iron-rich sulfides were actually observed, some of which were several tens of meters wide and more than 100 m long. Various exotic forms of marine life were also observed.

5.3B Hawaii

Because of various examinations and studies conducted in the late 1960's and early 1970's, a Federal-State of Hawaii Task Force was established in 1984 to evaluate the possible development of cobalt-rich manganese crust deposits located near Hawaii and Johnston Island. These deposits were in water depths ranging from 800 to 2,400 m. Recognition of the crust's resource potential and the presence of various crust-associated strategic metals led to further studies sponsored, at least partially, by MMS.

Research cruises sponsored by the MMS and organized by the Resource Systems Institute of the East-West Center and the Hawaii Institute of Geophysics were designed to provide the following:

- SeaMARC and seismic data (on individual seamounts of particular importance)
- manganese crust and substrate materials (for study and chemical analysis)
- detailed bathymetry
- bottom photographs of the cobalt-crust material

At most of the sites, an initial acoustic survey using the SeaMARC side-scan sonar mapping system aided the selection of stations for subsequent photography and sampling. Color photographs were obtained by a trigger-weight-actuated stereo camera system. Samples were obtained by rock corers, chain-bag dredges, and pipe dredges.

In November and December 1986, along with the USGS and the Bureau of Mines (BOM), the MMS sponsored a research cruise aboard the German research vessel *RV Sonne* to study manganese crusts in the Marshall Islands and in the Johnston Island Exclusive Economic Zone. The research work included dredging operations using various chain-bag dredges to recover manganese crusts and substrate rocks. A television-controlled grab device recorded the following:

- sampling of loose cobbles and fragments of manganese crusts
- sediment sampling by gravity corer and spade corer
- water sampling
- underwater photography and television records
- current meter deployments

Camera profiles, in combination with video tapes and bathymetric mapping using the Seabeam system, showed the variability of the microtopography, the crust abundance, and an initial resource evaluation of metals potential.

In September 1987 under a cooperative agreement with the NOAA, the MMS sponsored a study of the cobalt-rich manganese crusts of Cross Seamount and the hydrothermal deposits of Loihi Seamount off the coast of Hawaii. Shipboard-tethered bottom cameras and bottom samples collected by the submersible *Pisces V* allowed for study of the geological setting and stratigraphy of the manganese crusts located around these two seamounts.

5.3C Georgia

In September 1989, the MMS and the State of Georgia signed a cooperative agreement to:

- acquire four to six vibracore samples on Tybee and Skidaway Islands
- conduct seismic surveys to relate the offshore and onshore cores
- identify buried channels in the offshore area
- acquire and analyze vibracore samples
- complete the analysis of eight U.S. Navy cores
- conduct a radioactive sled survey
- sponsor a workshop to present results of these studies

The seismic work was completed during summer 1989, and the Georgia Geologic Survey completed drilling four cores on Tybee and Skidaway Islands during February 1990—the data are being analyzed. The seismic lines obtained were particularly valuable since the trackline plan was specifically designed to correlate several existing borings and wells. The work will serve to define further the regional stratigraphy of the phosphate-bearing Miocene-age deposits located offshore Georgia. In addition, the buried channel data may indicate areas of heavy mineral concentration since these deposits tend to concentrate along erosional shorelines (scarps) as well as erosional segments of accretional shorelines. Lag concentrations of reworked phosphorite may also exist within these buried features.

In June 1990, the Continental Shelf Division of the Marine Minerals Technology Center (MMTC), an institution associated with the University of Mississippi, conducted a seismic survey and a bulk sediment sampling experiment off the coast of Georgia. Initially, a seismic survey was conducted along the Georgia coast to provide additional data to delineate the geometry and trend of the previously mentioned buried channel features. A 2-ton phosphate bulk sample was collected in the area of the Savannah Light Tower for chemical analysis by the BOM Salt Lake City Research Center. The sample was collected using the MMTC Remote Placer Drill (a vibracoring device) modified for the project as a mini-borehole mining device.

In the MMTC experiment, the modified placer drill, along with an air compressor and crane, was mounted on a conventional COE barge. The drill was powered by a compressed air motor with pressured water pumped to the drill bit. This configuration provided enhanced drilling capacity and the ability to wash out a small cavity. After anchoring at the drill site, the crew set up a sample recovery system using a cyclone separator and a series of settling tanks to allow for recovery of fine-grained sediment before the water was returned to the ocean. The drill hole was successfully completed with a maximum penetration of 5.5 m, and enough phosphatic material was obtained to fill six 55-gallon containers. About 3 m of unconsolidated overburden consisting of medium to coarse sand, silt, and shell hash were initially penetrated; the drill then encountered a very hard layer of phosphatic, silty carbonate about 8-13 millimeters thick. The remaining 2.1 to 2.4 m consisted of alternating layers of phosphatic sand and clay.

After the bulk sample was obtained, cement was mixed with the remaining sediments in the separating tank, and a slurry was pumped successfully back into the drill hole. Underwater video recordings and diver observations of the experiment indicated that no sediment plume or turbidity occurred during the drilling or pumping operations. The information provided by this experiment will be useful to evaluate what appears to be an environmentally attractive technology for scientific research and potential for future recovery of offshore phosphate deposits (Drucker et al., 1991).

Analysis of the U.S. Navy cores was completed, and a report was produced in 1992 (Manheim, 1992). The report provides information on lithology, stratigraphy, phosphate distribution, and supporting chemical information on the eight cores, as well as interpretations of phosphorite genesis and the regional geologic and resource significance of the core data.

The results of the radioactive sled survey are contained in Henry and Idris, 1992. The sled survey data helped evaluate the economic potential of the heavy mineral deposits found in core and sediment samples obtained from the Georgia shelf.

A workshop was held at the Skidaway Institute of Oceanography, Savannah, Georgia, in April 1991 to present the results of much of the work conducted offshore Georgia.

5.3D Alaska

In November 1987, the Governor of Alaska requested that the MMS join the State in evaluating the feasibility of developing mineral resources in the waters offshore Norton Sound, Alaska. On February 5, 1988, the Secretary of the Interior signed a cooperative agreement establishing a Federal-State coordination team.

During the preparation of an EIS, concerns arose regarding the potential for bioaccumulation of toxic trace metals in organisms and the accuracy of existing water-quality data in the Norton Sound. The MMS subsequently contracted with Battelle Northwest to acquire trace-metal data using state-of-the-art seawater collections and analytical techniques. To conduct trace-metal analyses, human hair samples were also obtained from native women of childbearing age in Nome. The water sampling was conducted in June and September 1989; the human hair samples were collected during October and November 1989 and analyzed for levels of various trace metals, primarily mercury and arsenic. The results of these surveys indicate that the trace metal levels are not an environmental concern (MBC Applied Environmental Sciences, 1989b).

5.3E Oregon

Several research cruises took place offshore Oregon in September and October 1990. The objectives of this field program were to identify successfully the concentration, quality, and distribution of placer minerals deep in the sand section in at least two targets on the Oregon shelf, and to collect information on living resources and geology. The sampling plan for these cruises included the following activities:

- side-scan sonar surveys to identify and avoid areas of hard-bottom substrate
- magnetic and high-resolution seismic profiling
- vibracoring of sand samples 4 inches wide and up to 30 feet long
- vibralifting using a coring device to pump sand samples from the core barrel onto the research vessel
- benthic grab sampling
- bottom trawling to collect small fish and other animals
- seabird and marine mammal observations

At each of the targets identified for study, geophysical surveys located the targets and provided some preliminary information on the nature of the deposits. These surveys used magnetometers, high-resolution seismic profiling with a low-power sonic signal generator, and side-scanning sonar. On the basis of the information collected, a continuous core (vibracore) was drilled through the center of the presumed deposit, and a grid for bulk samples was established. Some difficulty was encountered during the vibracore operations which resulted in an insufficient quantity of material for analysis. Vibralift samples, however, were obtained and were returned to shore-based installations for examination. Observers onboard the research vessel kept note of visual sightings of seabirds and marine mammals. A report completed in June 1991 (Marine Taxonomic Services, 1991) contains the data and resulting analyses obtained from the benthic grab samples and bottom trawling. The collected data established a good baseline of information for the area surveyed.

5.4 Observed Effects

No adverse effects to the marine environment were reported during the field exercises or research activities associated with the MMS marine minerals program during 1987 through 1991.

Seismic profilers used for marine minerals investigations are less powerful than the normal seismic exploration systems used for deep penetration during natural gas and oil exploration. The sound is generated by a spark, air gun, or electromechanical clapper; explosives are almost never used. The towed string of sensors does not extend out behind the survey vessel as is common for natural gas- and oil-related seismic surveys. A deeply towed sled that "flies" several hundred meters over the seabottom is used sometimes.

Sampling devices used to obtain marine minerals or sediment samples disturb only an inconsequential amount of actual seabed material. Core samples are generally on the order of 5-10 cm in diameter, and penetration is usually no more than 2 m deep into the subsurface, except in the case of the vibracore/vibralift where penetration in very soft sediments may approach 6-7 m. As mentioned earlier, grab samples are usually about 0.3 m^2 in contact area and penetrate 15-20 cm. Since most marine mineral coring systems use sea water flushings, there has been no introduction of foreign materials during drilling or sampling operations. After the bulk sample was obtained in the Georgia experiment, cement was mixed with the remaining sediments in the separating tank, and a slurry was pumped successfully back into the drill hole. Underwater video recordings and diver observations of the experiment indicated that no sediment plume or turbidity occurred during the drilling or pumping operations.

The amount of biological samples obtained during these field activities was small in amount compared to the known populations. Marine life was not disturbed by the marine minerals research activities during the report period.

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The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Royalty Management Program** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.